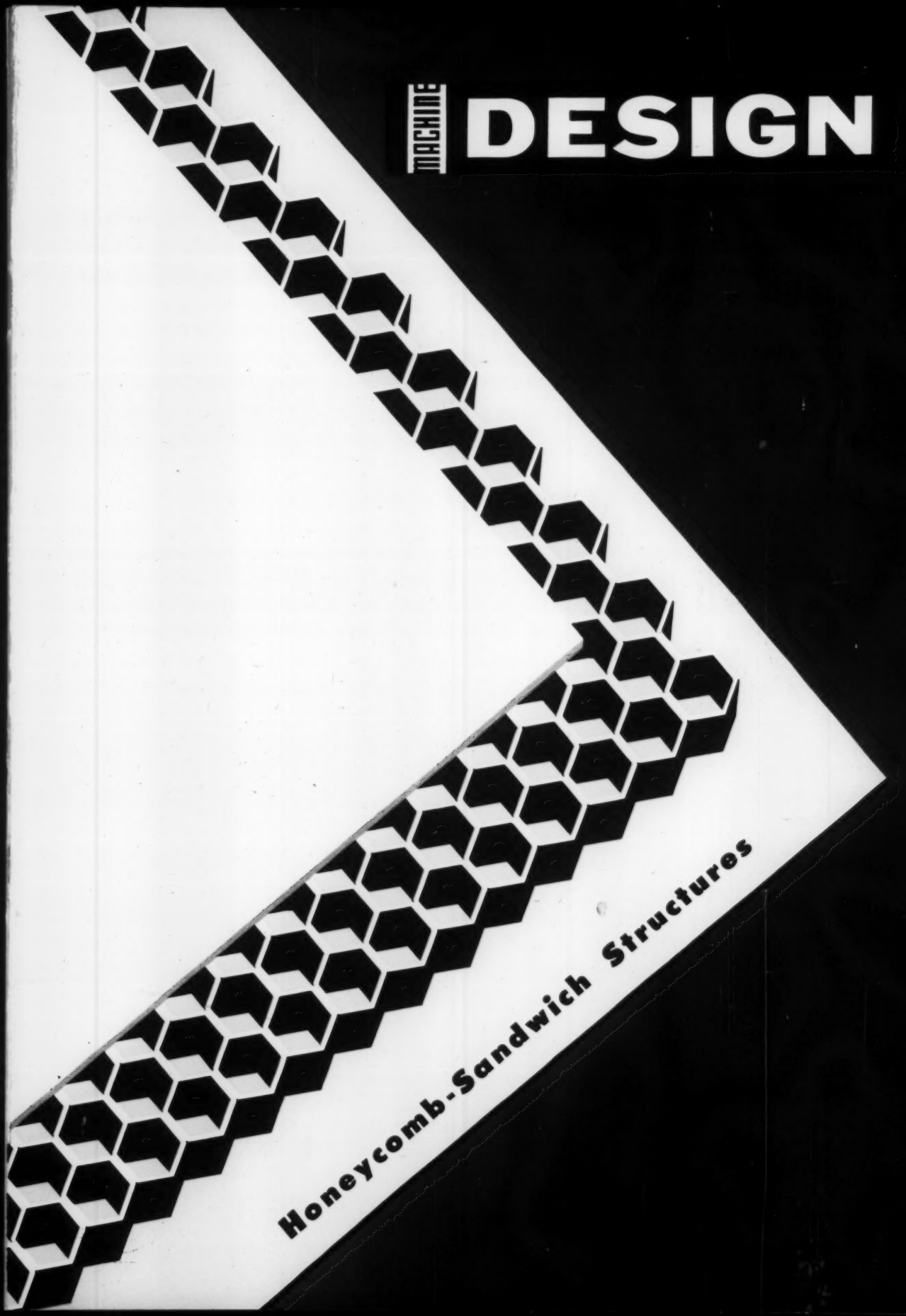
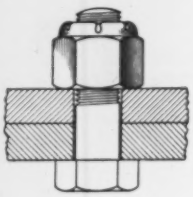
MACHINE DESIGN



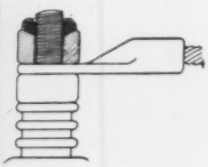
Honeycomb-Sandwich Structures

Ten fastening problems solved by ELASTIC STOP® nuts

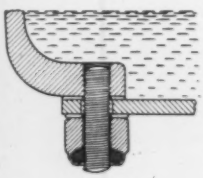
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

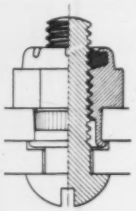


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

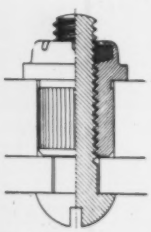


To seal bolt threads where leakage past stud threads must be prevented.

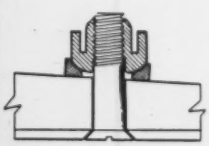
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

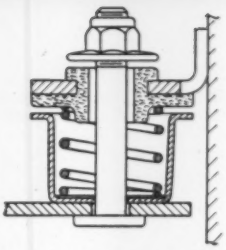


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

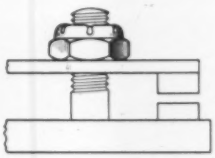


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

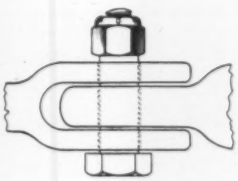
LOCKED ANYWHERE ON THE BOLT



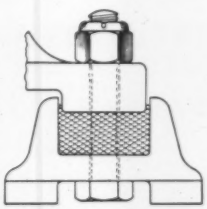
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. R40-54.

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2330 VAUXHALL ROAD, UNION, NEW JERSEY

Alemite "Tri-Duty" air line controls!

All-New...for the cleanest, driest, best-regulated air line lubrication

Automatic Water Separator! Removes all of condensate, all the time. Traps dirt particles to prevent damage to sensitive air line devices. Handles all air line pressure up to 200 PSI and flow volume from 5 to 50 CFM.

Air Regulator with Gauge! Assures accurately controlled air – prevents erratic operation and damage to equipment. Adjusts to any pressure up to 200 PSI.

Automatic Air Line Lubricator! Provides automatic lubrication to air-operated mechanisms. Air stream controlled by compensating Venturi valve. Nine-ounce capacity.

All-New features offer outstanding advantages:

1. Single Unit Control Lubricator. Regulates the exact oil output required.

2. Visual Oil Counter. Oil sight dome in lubricator permits visual observation and count "per-drop" of lubrication.

3. Uniform Oil Mixture. Regardless of air pressure and volume!

4. Consistent Output. Oil and air mixture proportionately constant.

5. Easily Installed. Straight "inline" pipe connections . . . ½" p.t. inlet and outlet ports.

6. Wide Oil Range. Handles all viscosities of oil up to 500 SSU at 100° F.

7. Continuous Operation. Oil reservoir is refillable while unit is in operation.

8. Instant Oil Feed. For intermittent or continuous tool operation—no lag!

9. Filter Oil Tube. Removes all contamination from oil passing into air line.

10. Concentric Venturi Design. Assures constant, uniform mixture of air and oil.

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12. Effective Control of Air Flow. Air Regulator eliminates excessive pressures and sudden surges.

13. 100% Condensate Removal. Water Separator removes and automatically dumps 100% of the condensate present in air lines.

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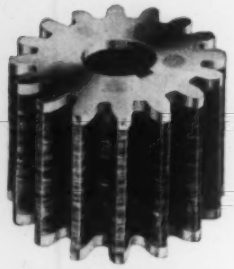
C/R Rawhide and non-metallic pinions and gears



C/R RAWHIDE SPUR GEAR

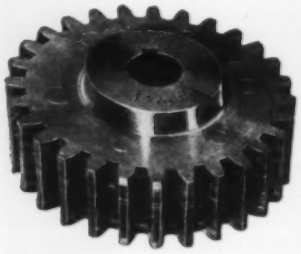
C/R RAWHIDE BEVEL GEAR

C/R NYLON GEAR

transmit power quietly, soak up shock loads,

C/R BAKELITE TIMING GEAR

C/R MICARTA GEAR



C/R RAWHIDE SPUR GEAR WITH HUB

and make metal mating gears last longer!

C/R Rawhide and other C/R non-metallic gears transmit power quietly and efficiently, with less vibration than other gears. These pinions take all the wear, soak up shock loads up to three times their rated capacity. You'll find they actually protect expensive metal mating gears, prolong the life of the machine.

Where high temperature and humidity are factors, C/R gears cut from Nylon, Bakelite, Textolite, Formica, Micarta or Fabroil are generally recommended. C/R also cuts special purpose gears and pinions of material such as Synthane, Spauldite, Celeron and Insurok — as well as all metallic gear materials. C/R gears range in size from 1" O.D., ¾" face, up to 30" O.D., 12" face. Diametral pitches range from 1¼ to 64; horsepower ratings go up to 250 hp.

Our experience in cutting gears for all types of applications is unsurpassed in the industry. May we help you? Write for our illustrated C/R Gear Booklet.

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C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots

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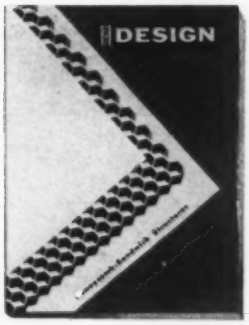

Front Cover: A simple pattern of honeycomb core combined with two facing sheets to make a sandwich structure is used by artist George Farnsworth to illustrate Andrew Marshall's article on Page 126.

May 15, 1958

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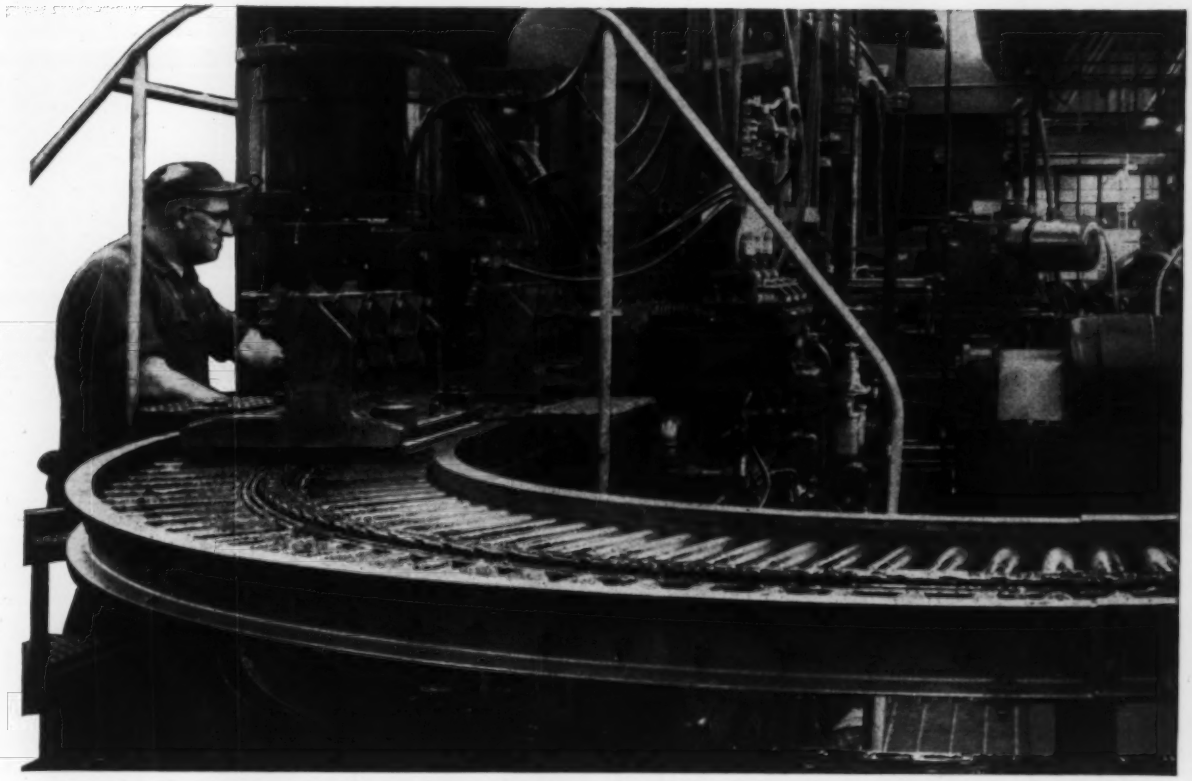
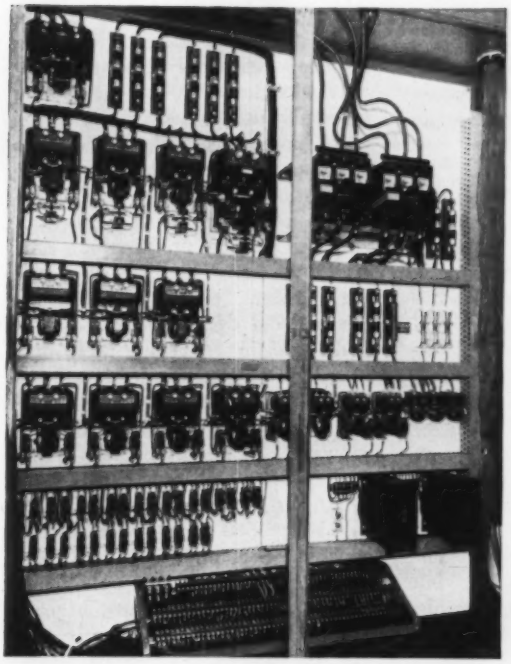


Eaton Manufacturing Company automation line depends on CLARK Type "CY" Starters to minimize costly downtime...



In complex automatic machines used today, dependable electrical controls are essential to continuous operation.

Typical of such machines is this automation line at the Pump Division of Eaton Manufacturing Company in Marshall, Michigan. Designed and built by the Avey Division of The Motch & Merryweather Machinery Co., it performs 132 operations on automatic power steering pump bodies. The control system contains 15 Clark type "CY" starters, in sizes from 1 to 3, designed for dependable, heavy-duty, long-life operation.

Every panel component is a vital link in the production process. Because Clark Type "CY" starters employ an exclusive principle of arc-quenching, using double-break contacts and strong, multi-turn magnetic blowouts, contact life is greatly increased. Throughout industry, thousands of Clark starters are giving on-the-job proof that this means less maintenance, reduced downtime, and increased production and profit.

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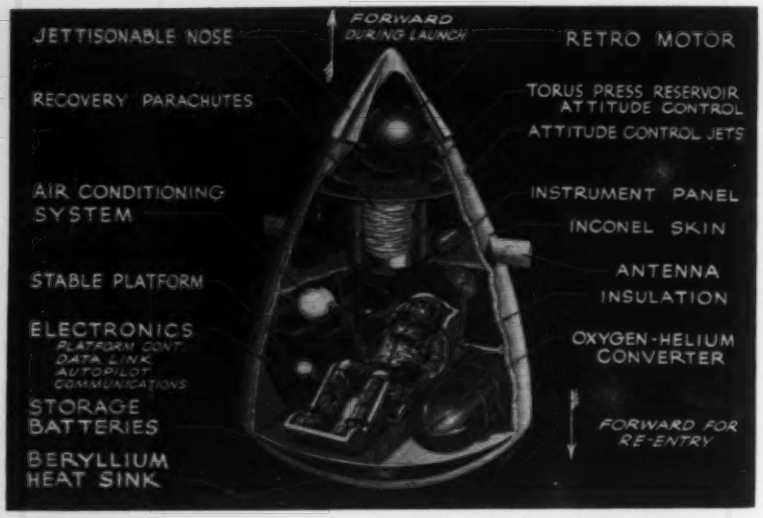
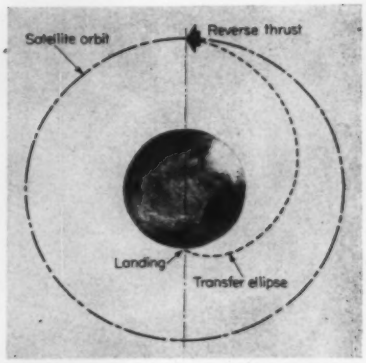


Ballistic satellite capsule proposed by Northrop Aircraft would house one man and necessary survival equipment. Once in orbit, capsule would be positioned blunt-end first to provide high drag needed for re-entry phase.



Satellite recovery would begin with firing of reverse-thrust rockets at point 180 deg from desired landing spot. Loss of speed would throw vehicle into an elliptical orbit which would intercept the earth. Parachutes opening at 30,000 ft would provide final descent.

Three-Year Plan to Orbit Man Proposed by Aircraft Builder

First tests, using animals, would be followed by firing one-ton manned capsule into orbit at altitude of 200 to 300 miles

HAWTHORNE, CALIF.—A three-year program for putting a recoverable manned space laboratory into orbit has been proposed by Northrop Aircraft Inc. Using knowledge and hardware now at hand, Northrop suggests the vehicle as an economical and logical predecessor to military space ventures.

The bullet-shaped space capsule would be launched into orbit by available rocket engines. It would use a celestial navigation system similar to the one Northrop developed for the Snark missile.

Once in orbit, the capsule would make several revolutions until its exact position could be determined by tracking stations. Low thrust gas jets activated by signals from the navigation system would then turn the vehicle blunt end forward.

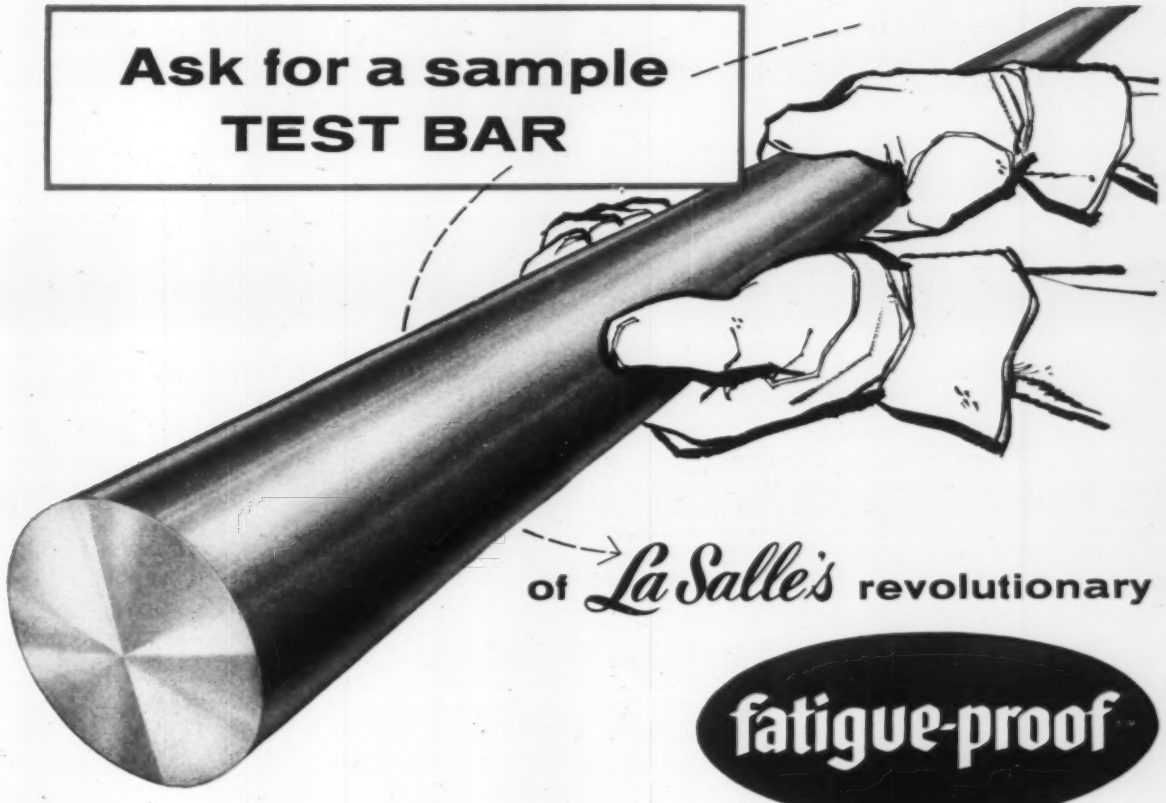
For atmosphere re-entry, reverse-thrust rockets would be fired at a point about 180 deg from the desired landing spot. Re-entry would be at a shallow angle, about 2 deg from the local horizontal. High drag would slow the capsule from 25,000 fps to 1000 fps (Mach 1) by the time it had descended to an altitude of 60,000 ft. A parachute would be opened at 20,000 to 30,000 ft, insuring a gentle landing.

Difficult problems will be encountered in the operation, but none appear to be insurmountable, according to Northrop officials. The launching will require somewhat higher energies than those being used now, but is definitely within the state-of-the-art capability. Guidance accuracy during boost is less critical than that required for an ICBM.

A more critical problem is controlling the re-entry phase. To achieve a reasonably accurate landing—within a 100-mi circle—the reverse-thrust maneuver would require precise control. Velocity at end of the reverse thrust, the direction of thrust, and the timing of the maneuver would be critical.

Other re-entry problems are generally the same as those of a ballistic missile, mainly aerodynamic heating and deceleration. If a normal ballistic trajectory were followed, surface temperatures of several thousand degrees F and deceleration of 30 to 50 g would result. However, by re-entering at a low angle with a high-drag shape, maximum surface temperature is limited to about 1500 F and deceleration to about 8 g, and these maximum values would occur for only about 1 min. Thus temperature in capsule would rise only slightly and the passenger's g-tolerance would not be exceeded.

Ask for a sample TEST BAR



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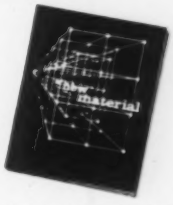

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Circle 407 on Page 19

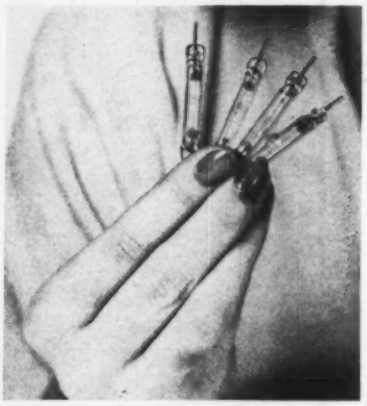
TWO-PLACE VTOL, designed by Umbaugh Aircraft Corp., Ocala, Fla., is a new entry in the private aircraft market. Equipped with pusher propeller, the new craft is fast—100 mph, and safe, since rotor is always in autogyration. It climbs 3000 fpm, needs no airport, and gets 15 mpg of fuel. Total operating and maintenance cost is claimed to be 5 cents per mile. The craft can be converted for dusting, spraying, or cargo, and is available with floats. Umbaugh is tooled up to produce 1000 units per month.

New Group to Study History of Technology

CLEVELAND—Society for the History of Technology is the name of a new organization formed by interested scholars, engineers, and scientists to study the impact of technology on society. The new group will sponsor meetings at which various aspects of technological history will be investigated. At its first program, the Society will cosponsor the meeting of the Humanistic-Social Div., American Society for Engineering Education, at University of California, Berkeley, June 16-17.

The Society also plans to publish a quarterly journal, *Technology and Culture*, devoted to the study of the development of technology and its relations with society and culture. First issue is scheduled for Fall, 1959.

Representatives from education, government, and industry comprise the Executive Committee and Advisory Council. Applications for charter membership ($10) and requests for additional information should be directed to Professor Melvin Kranzberg, Room 315, Main Building, Case Institute of Technology, Cleveland 6, Ohio.



RAPID BLINKING, at a maximum rate of 10,000 times per sec, makes GE's new FT-30 flashtube naturally adapted to quality control applications. A stroboscopic effect is achieved by adjusting flashing rate of the flashtube to coincide with the movement of the product, material, or machine under study. Advantages claimed for the FT-30: It is half the size of flashtubes currently in use, and will operate on lower voltages. Like larger flashtubes, light output of the FT-30 can be varied, and both duration and rate of flash are adjustable. Future uses of the new flashtube include computer applications which require light-sensitive processes.

Topics

Sound from the sun is provided through a pair of hearing-aid eyeglasses developed by Zenith Radio Corp. Built into the glasses frame, the hearing aid contains a tiny, sun-rechargeable nickel-cadmium storage battery which provides power when the wearer is not in the sunlight.

• • •

Sixes have increased in popularity with this year's automobile buyers. Cars with six-cylinder engines account for about 22 per cent of 1958 production to date; output of sixes in 1957 was 17.3 per cent of the total.

• • •

Teen-age missiles epidemic has spread to the extent that there are 1200 young rocket-building enthusiasts in metropolitan New York alone. These experimenters have appealed to the Army for a safe testing ground, as well as technical advice. Problems revealed to Army personnel by the youngsters range from blasting out a "celler" window to recovery of a successfully fired missile.

• • •

Meanwhile, back at a launching site on the Mojave Desert, 200 grade-school children witnessed the firing of a small rocket—the last step in a junior space technology course given by four engineers at Convair-Astronautics Div. of General Dynamics Corp. For five successive Saturday mornings youngsters from the ages of 7 to 15 learned the basics of rocketry. Lectures on fundamentals of physics, chemistry, electricity, and mathematics were supplemented by demonstrations, functional models, and movies furnished by the Air Force.

• • •

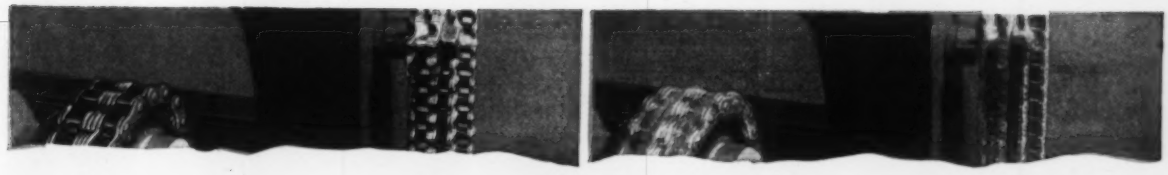
Full cycle: An electronic computer that runs on electricity produced by atomic power is used by researchers at the Argonne National Laboratory to provide data on improving production of atomic power.

• • •

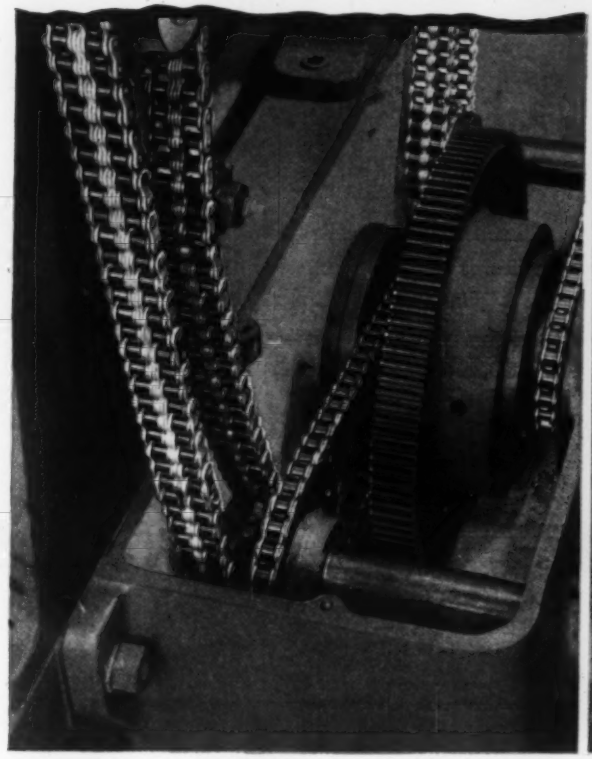
New record machine takes your money and gives you—not three minutes of music—but the whole record. Machine is the "first workable" automatic phonograph record vendor, made by Columbia Records.

• • •

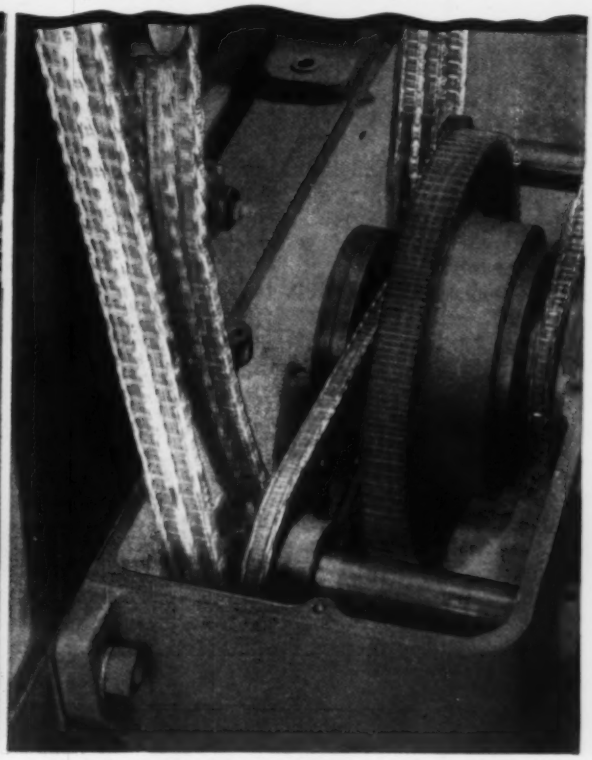
Substitute for jute used to make sandbags is a special paper developed by Army engineers. Paper in the sandbag is knitted to add strength. It has all the physical qualities of its jute counterpart, and it stacks and handles satisfactorily. Chemical treatment of the paper provides both wet strength and fungicidal protection. Field tests have shown the paper sandbag can survive 60 days under the most severe weather conditions.



To static strength . . . add *dynamic strength*



RESISTANCE TO TENSILE STRESS is achieved with properly heat-treated, accurately machined side bars made of premium steel and fitted with properly hardened pins, bushings, rollers.



STRENGTH OF CHAIN IN MOTION results from such refinements as pitch-hole preparation, mirco-finish of parts, special processing of side bars, pre-lubrication, rigid quality control.

Why LINK-BELT roller chain takes stresses in stride

ON *tough-service* drives and conveyors, Link-Belt precision steel roller chain consistently delivers longer life. That's because its *greater dynamic strength* withstands the starting shock and centrifugal loads of severe operation.

Reports from users prove the effectiveness of Link-Belt's manufacturing extras that add to greater dynamic strength. Shot-peened rollers give greater fatigue life and ability to withstand impact . . . lock-type bushings end a common cause of chain stiffness . . . pre-stressing provides uniform load distribution . . . closer heat-treat control insures uniformity.

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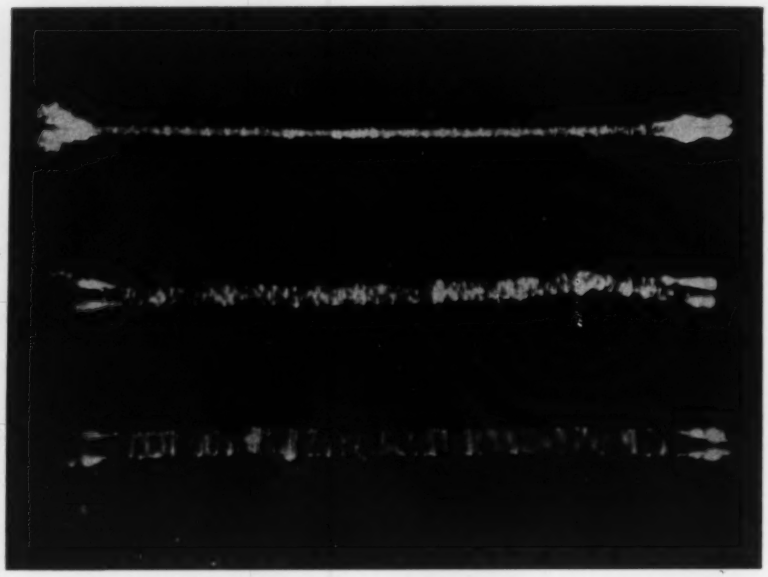
Camera Assembly Uses Ultrahigh-Speed Shutter

"Kerr Cell" Unit Operates In 5-Billionths of a Second

PASADENA, CALIF.—The fastest high-resolution camera assembly in the world, with an effective exposure time as brief as five-billionths of a second, is being used for the photographic study of ultrahigh-speed phenomena. Heart of the assembly is the Kerr-cell shutter unit which, used in conjunction with a pair of polaroid screens, allows light to pass through it when a high voltage is applied.

The camera assembly, developed by Electro-Optical Instruments Inc., consists of four units; camera, modulator, power supply, and shutter module. A Crown Graphic "45" camera, fitted with a special adapter for attaching to the modulator cabinet, is furnished as part of the assembly. The electronic modulator supplies the high-voltage pulse for shutter operation and has a separately packaged power supply. A synchronizing pulser in the modulator permits triggering both the pulse-forming network and the phenomenon under study.



Five-billionths-of-a-second camera shutter stops action of exploding wires at 20, 30, and 40 billionths of a second. Explosions resulted from switching a 1000-mfd capacitor charged to 25,000 v through 1-mil aluminum wire. The camera unit was developed by Electro-Optical Systems Inc., Pasadena, Calif. under contract with U. S. Army Ordnance group.

The shutter module consists of a hydrogen thyratron, pulse-forming network, and the shutter unit. It can be physically attached to the Crown Graphic "45" or to any other camera. Connected by a flexible cable, it can be separated from the modulator cabinet and operated at a remote location.

Metals Matters

Cold extrusion of titanium into hollow shapes has been accomplished by Battelle Memorial Institute for the Air Materiel Command, USAF. In a 700-ton hydraulic press, 1½-in. slugs of unalloyed titanium were backward extruded into cups 3 in. long with wall thickness of 0.22 in. Forward extrusions are cup-shaped billets with 1½-in. OD, ⅞ in. ID, 0.15 in. wall thickness. Surface finishes are 30 to 60 mu in. Increases in tensile strength of 30 per cent are obtained.

• • •

Micrograin nickel—hard and flexible—has been developed by Metachemical Processes Ltd., Crawley, England. Electroforms of Micrograin are currently used successfully on aircraft propellers to protect deicers from rupture due to stones and hail. To make a Micrograin electroform, first step is casting a master mandrel having contours of the final part. The casting then receives an electrically conductive plastic coating several mils thick. The coating is flash-plated with copper, then nickel to desired thickness, tapered if required. Fine nickel grains are credited to the conductive plastic, but originators aren't sure. For micrograph analysis, they haven't found a way to etch the deposit.

• • •

Largest titanium plate, light gage, has been rolled by Titanium Metals Corp. Made of Ti-75A alloy, the plate measures 75 by 224 in. Nominal thickness is 3/16 in. Plate was made for chemical process vessel holding corrosive material.

• • •

Freedom from silver marks a new process for salvaging the stainless steel in structures brazed with silver alloy. If structures are simply melted down, silver enters and contaminates the stainless alloy. The Martin Co., Baltimore, soaks stainless honeycomb panels in 50 per cent nitric acid for 20 hours at room temperature. This dissolves the silver, frees structure parts, enables stainless and silver to be recovered independently.

• • •

Custom alloys in small batches are in prospect with the announcement of the Strategic-Udy process for the reduction of iron ore to pig iron, a development of Strategic Materials Corp. and Koppers Co. Equipment used includes a direct-fired rotary kiln, an electric furnace, and materials-handling units. Iron ore is mixed with low-cost carbon (coal) then fed into the kiln. Emerging from the kiln at 1100-1300 C, the charge enters the reducing zone of the furnace for quick, complete reduction. In addition to small lots and selective removal or addition of alloying elements, advantages of the new process include: Wide range of ore sizes admissible, range of fuels, low power requirement. Disadvantage, for the present, is cost.

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GEAR STEEL

Gears are a special steel problem. Controlled grain size, freedom from porosity, segregation, and non-metallic inclusions are essential. Chemistry is critical.

For these reasons, gear manufacturers insist upon electric furnace steels. Aristoloy, produced by the electric furnace method under stringent controls, from raw materials to melting, meets these requirements.

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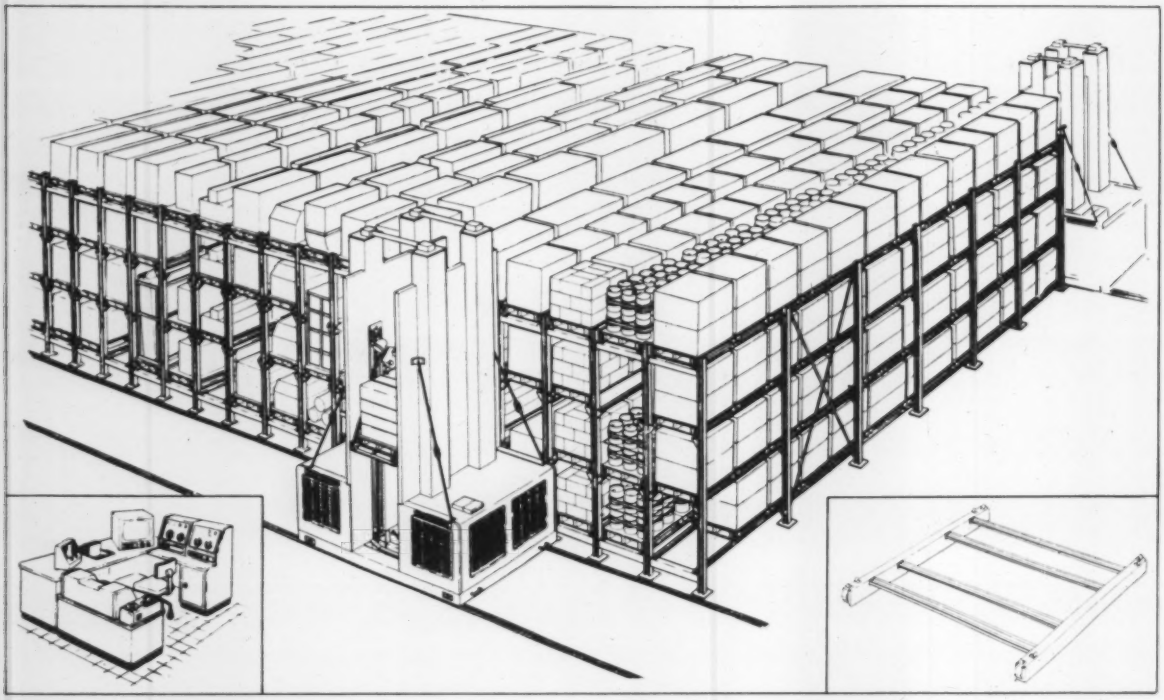


A series of sloped rails supported by uprights serve as racks in Pesco's new automated warehouse. Rack cells are served by an automatic loader and unloader stationed at opposite ends. One man in the console room, left, controls the operation aided by closed-circuit television. Freight is stacked on conventional wooden pallets which are previously mounted in special flanged-wheel platforms, right.

Palletized Storage, Automated Warehouse Are One-Man Job

Track-Mounted Lift Trucks, Pallets on Wheels Controlled Electronically, Monitored by TV

BEDFORD, OHIO—Fully automatic, a new warehousing system developed by Pesco Products Div., Borg-Warner Corp., uses specially designed racks serviced by track-mounted, self-propelled loaders and unloaders. One man operates the warehouse by dial or pushbutton from an electronic console. With a racking system four cells high, designed for handling an average pallet (4 x 4 x 4 ft), a 50,000-sq ft Pesco system will accommodate 12,000 pallets. This compares with 6000 pallets in a conventional warehouse.

A typical installation with single loader and unloader operates on a 2-min cycle for loading or unloading. Production capacity is thus rated at 30 pallets in and 30 pallets out per hr. If desired, a semi-automatic system can be designed for either fork truck or bridge crane feed.

Storage racks in Pesco's system consist of a series of sloped rails supported at regular intervals by uprights. Spaces formed by the rails and uprights are called cells and racking systems are generally designed to be 3 or 4 cells high. Rail length is optional and may accommodate up to 15 pallets. Conventional wooden pallets are used, mounted in small, wheeled platforms.

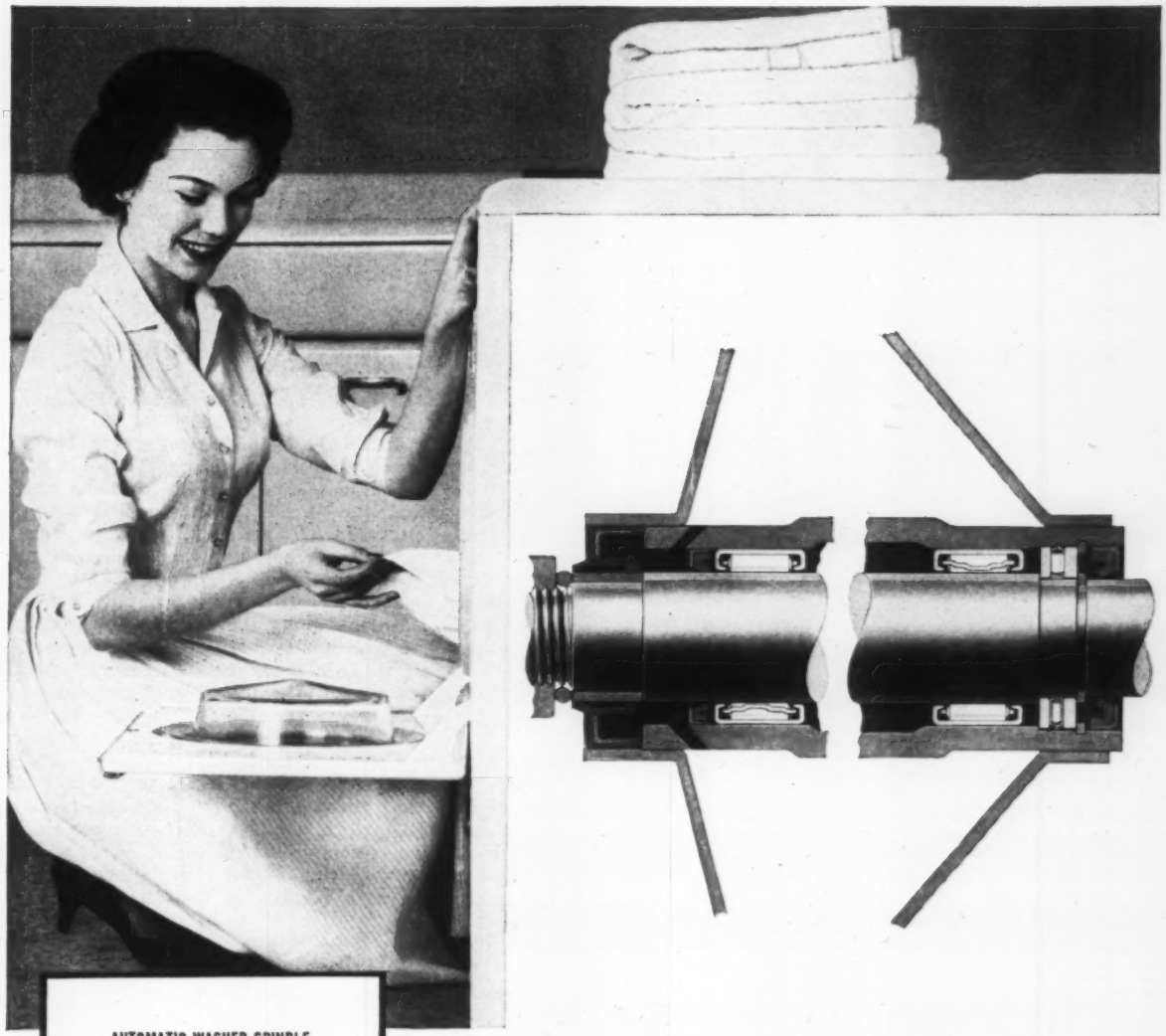
Cell dimensions are tailored to meet the needs of a given installation. The racking system can be designed to accommodate pallets from 32 in. square to 5 ft square with height of each cell determined by the palletized product. Provision is made for quick alteration of cell height.

Automatic loader and unloader move on tracks paralleling the rack face. Each is designed to accommodate two pallets and can handle a load of 8000 lb.

In a typical loading cycle, the operator first dials row number and cell height, identifying the cell location for pallet delivery. The loader unit picks up the load and determines the correct row by means of a photoelectric counting system, which counts inches rather than rows for maximum accuracy.

Operation of the unloader is identical and reversed, except that a third digit may be dialed to deliver the selected pallet to a predetermined unloading point.

To permit mixed product storage, return rails can be installed in the racking system. With this arrangement, it is possible to pick pallet number as well as row number and cell height. When a signal to pick other than the end pallet is received by the unloader, it moves to the designated row and cell height and first transfers to the return rails the pallets ahead of the one specified. The desired pallet is then picked and unloaded.



AUTOMATIC WASHER SPINDLE

Is equipped with two Torrington Drawn Cup Roller Bearings for operating stability and long pregreased life. Spindle thrust is handled by one compact Torrington Needle Thrust Bearing.

New Low-Cost Bearing Advances Design and Performance of Home Appliances!

The new Torrington Drawn Cup Roller Bearing opens new possibilities for improved design and performance of washing machines and other major appliances.

For the first time, the advantages of drawn cup outer race construction are available in a precision, compact and low-cost roller bearing. This construction permits exceptional compactness, simple housing design and easy installation by press fit. Highly efficient roller guidance and ample provision for lubricant storage insure smooth starting, cool running and extended service life, especially where high-speed operation and long pregreased life are required.

Today's designer now can secure the advantages of efficient anti-friction performance at low cost in an exceptionally lightweight, compact design with the new Torrington Drawn Cup Roller Bearing. For engineering assistance, call on your Torrington representative. And write for the new bulletin, "Torrington Drawn Cup Roller Bearings." **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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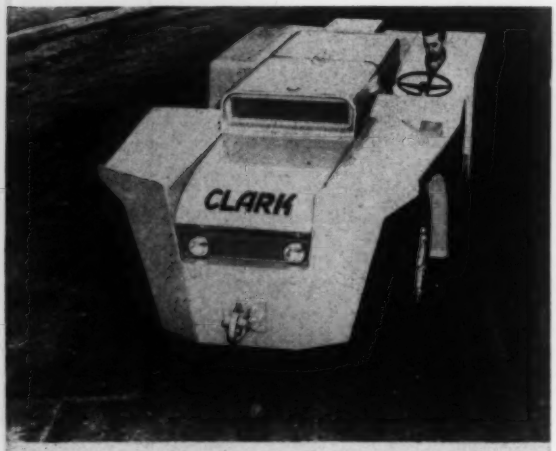
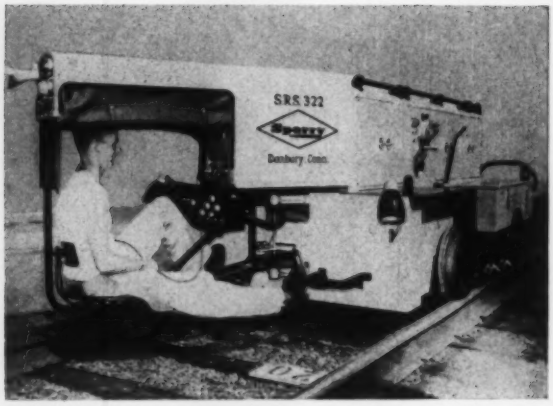


SQUATTY VEHICLE will tow giant jet passenger liners. This Jetow tractor, built by Clark Equipment Co., is only 5 ft high, has four speeds both forward and reverse, features individual rear-wheel braking for tight turns. Modern automotive features include power steering and full-power shifting. Equipped with a 272-hp, six-cylinder Hercules gas engine, the tractor utilizes torque converter with 3-to-1 multiplication factor. Heavy-duty rear axle is double reduction type, final reduction being accomplished at each drive wheel through planetary gearing. Photo (left) shows tractor towing 200-ton B-52 bomber in demonstration tests at speeds of 5 mph.



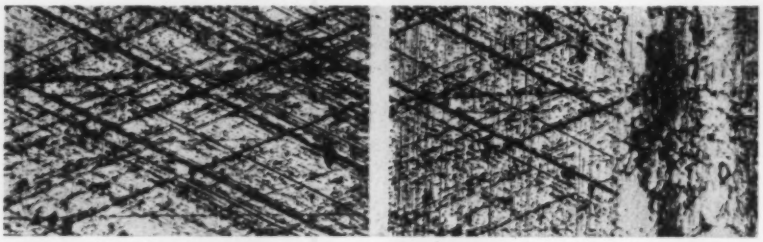
LOW-SLUNG ULTRASONIC detector car (above) checks subway rails for hidden defects. To solve the problem of steep grades—some running to 8 per cent—low clearances, and ventilation difficulties, Sperry developed a special car, propelled by a Kohler Electric Plant. The electric plant also supplies power to the electronic equipment aboard the car, used to detect fissures and other defects in the rails before actual failure. Moving along the rails at slow speed, the car sends electric impulses through the rail head. When a defect is discovered, the detector car spots the rail with paint, marking it for later removal.

Replicas for Light Microscopy Document Surface Studies

Aid Engine Wear Study, Enhance Microscopy Technique

COLUMBUS, OHIO—The use of plastic replicas for following the progress of wear in engine cylinders has not only contributed to a better understanding of what causes scuffing in engine cylinders, but has led to development of a new microscopy technique as well. Microscopist A. P. Young of the Battelle Memorial Institute, who conceived the idea of this use for replicas, reports at least two advantages over conventional light microscope techniques:

1. Replicas can be used for microscopic examination of surfaces inaccessible because of size or shape to direct examination.
2. A series of replicas taken at stages during a test constitutes a graphic history of the sample being studied.



Plastic replicas and a light microscope were used in making these pictures of the same area of engine cylinder wall before and after scuffing occurred. Intermediate state during the engine run and before scuffing occurred is shown at left. Rough vertical bands in the picture on the right, which was taken later, indicate the occurrence of scuffing. The diagonal honing pattern, seen in both photos, made it possible to locate the same area in replicas made of the cylinder wall at various stages in the engine run.

To make replicas of engine cylinder walls, scientists removed the engine head at set intervals and lowered the pistons. Replicas were made by dipping sheets of cellulose acetate in dioxane and pressing them against the cylinder walls.

Refinements in the basic technique made it possible to obtain replicas almost completely free of bubbles and other defects. A thin layer of gold was evaporated on replicas of particular interest to enhance reflectivity and contrast when they were examined under the light microscope.

Mach-28 Speeds Produced In New Helium Wind Tunnel

SCHENECTADY, N.Y.—Problems associated with the ultrahigh-speed flight of satellites, missiles, and meterorites are being studied at General Electric Research Laboratory in what is believed to be the world's largest and fastest helium wind tunnel.

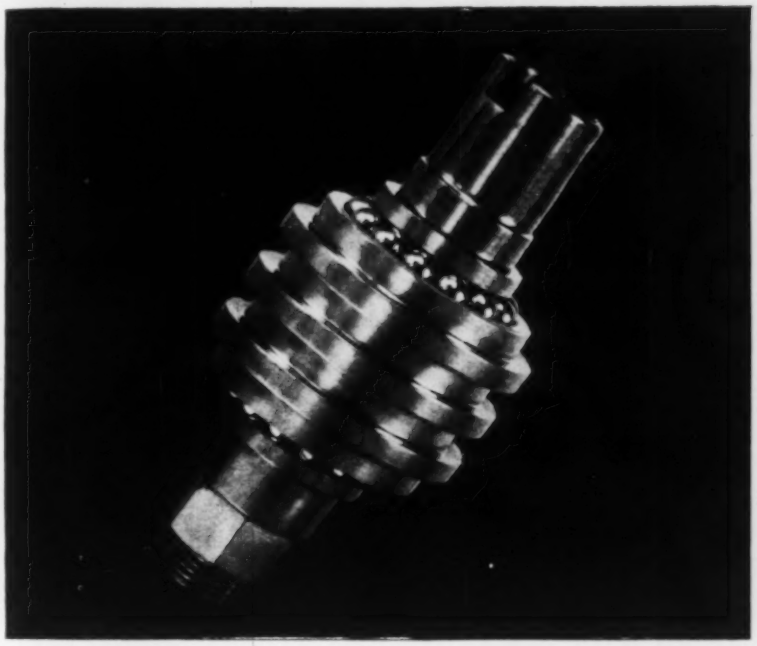
The new facility has produced the highest Mach numbers ever attained in a wind tunnel, reaching velocities in helium corresponding to Mach 28. Speeds corresponding to Mach 25 in air were needed to launch the first U.S. satelite, Explorer I. A Mach number of 35, based on sea level sound velocity, would be necessary for an object to escape the earth's gravitational field. These speeds may be reached in future experiments.

In conventional wind tunnels, big compressors send a stream of air past the model being studied. In GE's helium tunnel, the compressed gas is stored in tanks and allowed to escape through a nozzle into the test section, in which a near-vacuum is maintained. As the expanding gas rushes down the tube past the model, very high velocities are produced, together with very low temperatures and pressures. Static temperatures as low as 2 or 3 degrees above absolute zero have been obtained during runs lasting from seconds to minutes.

Helium is used in the tunnel to avoid complexities that are encountered in studying high-speed flight in air. At extremely high speeds, air breaks down into an assortment of elements, compounds, and ionized particles that bears almost no resemblance to the air we breathe. Helium, the stablest element, is not subject to the changes that occur in air's properties and composition. In addition, helium has an extremely low liquefaction temperature, which ensures that it will not liquefy, as air would, as it passes through the tunnel passages and through the shock waves that occur in front of the model.

Test sections with diameters of 3.6 or 6 in. can be used in the tunnel, depending upon the Mach number desired. Models up to 1 in. in diameter can be studied, with data taken by means of schlieren photographs and manometer readings.

Dual-Purpose Ball Bearing Solves Tough Design Problem



Anti-friction bearings made for specific applications free the designer from the limitations imposed by "standard" bearings, and permit a better product at lower cost. These advantages are demonstrated by the bearing shown above, which is used in an atomic reactor control mechanism. Consider the following features:

- The outside diameter has a tooth form that engages a lead screw. This saves the space, weight and cost of separate parts that would otherwise be required, and avoids variations resulting from a "stack-up" of tolerances.
- The bearing runs in hot water under pressure, at 350°-500° F.; and the water is its only lubricant.
- It withstands the corrosive action of high-purity water at the required operating temperatures.
- Low torque is essential; and dependability throughout a long life is of vital importance.

We obtained the required characteristics through the use of special alloys, and through very close control of bearing geometry, dimensions, and surface finish.

NEW 24-PAGE BEARINGS BULLETIN tells about the factors involved in a wide range of special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*

INDUSTRIAL TECTONICS, Inc.

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MANUFACTURERS OF PRECISION BALLS AND BEARINGS

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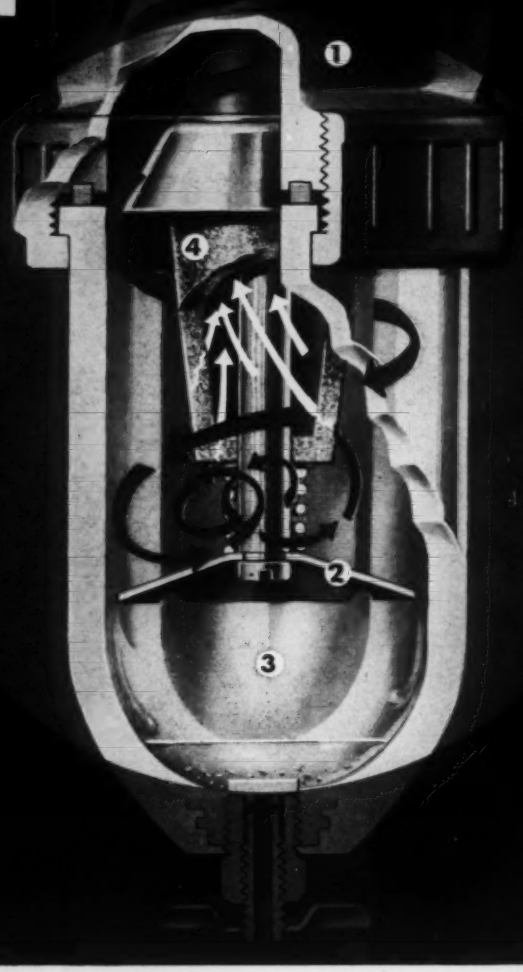
WESTERN DIVISION PLANT: COMPTON, CALIFORNIA



Curved inlet **1** directs incoming air in downward helical pattern. Larger impurities and condensate are "thrown out" by centrifugal action, collecting on bowl sides and spiraling downward past baffle **2** into quiet chamber for draining-off. Baffle traps sediment in quiet chamber **3** and allows only dry air centrifugally cleaned of larger impurities to reach filter element **4** where finer particles are filtered out.

New "TORNADO ACTION" of high-efficiency filter really cleans air flowing to pneumatic equipment

You add service life to equipment and reduce maintenance costs to the minimum with Watts High-Efficiency air line filters. The exclusive Tornado Action designed into Watts filters delivers really *clean* dry air.

WATTS REGULATORS — sensitive "ASPIRATOR ACTION" maintains more uniform pressure

Aspirator acts directly on diaphragm giving instant compensation for fluctuating loads . . . provides precise control and stabilizes pressures reaching individual pieces of equipment.

Write for free technical catalog. Charts, diagrams, and performance data enable **you** to specify the correct Watts pneumatic equipment.

You can expect *high efficiency* from the advanced-design Watts line of filters, regulators and lubricators. Specialists in protection and control devices since 1875, Watts is creating new *standards* of efficiency in pneumatic operation.

WATTS LUBRICATORS — exclusive "BY-PASS PICK-UP" assures efficient lubrication

High velocity venturi section provides efficient atomization at air flow rates as low as 1 CFM. Automatic bypass valve assures complete atomization with negligible pressure drop at high air flow rates. Result: wide range performance *in a single unit.*

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

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MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

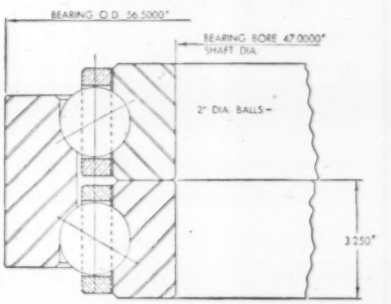
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

KAYDON Types of Standard and Special Bearings:
Taper Roller • Ball Radial • Ball Thrust
Roller Radial • Roller Thrust • Bi-Angular Bearings

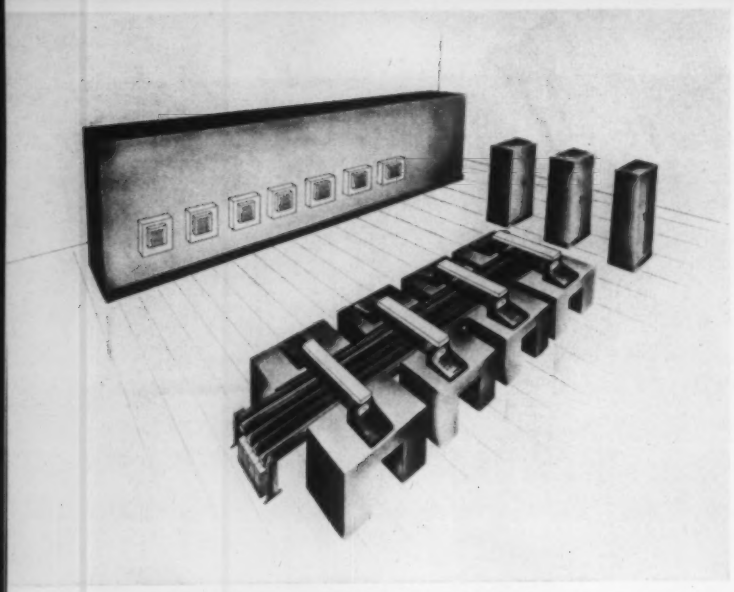
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K543

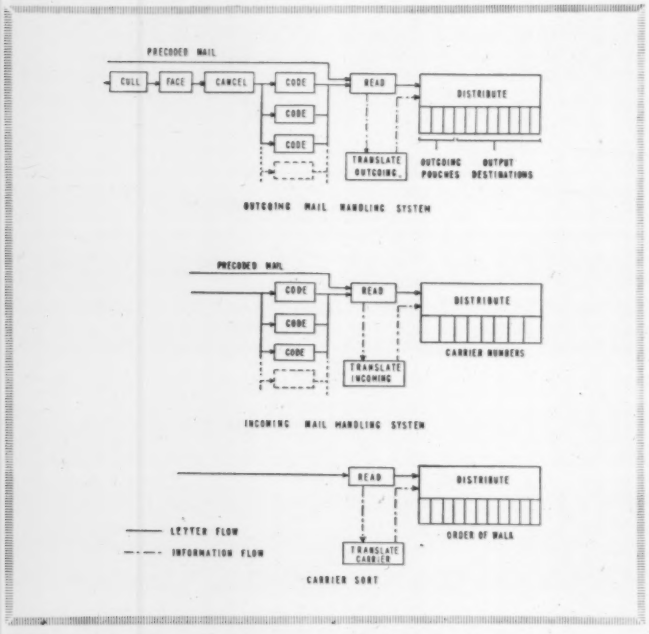
PRECISION BALL AND ROLLER BEARINGS

Circle 413 on Page 19



Dot codes will direct machines to sort the mail

Sorting sections in post offices in the future may look like this, according to the National Bureau of Standards. The layout is composed of units currently under development. In the foreground are coding stations to which mail is brought automatically and faced toward coding clerks. The clerks read the addresses and press keys which print corresponding dot-pattern codes on the backs of the envelopes. Coded letters then pass to automatic reading units at upper left. Impressions from the readings are registered in the translators, upper right, which control detail sorting into "out" bins. Three translators control incoming, outgoing, and carrier mail, respectively.



Co-operation from business can help cut steps

Mail tracks are the solid lines in these block diagrams which show routing of letters and control pulses through the NBS automatic sorting machine. Outgoing mail originates in the community a post office serves. It must pass through cull, face, and cancel operations unless precoded and precanceled, as with business mail. Most important stations are the coding points where clerks determine and type codes. All other operations, some governed by the printed codes, are virtually automatic.

Bigger burdens, growing daily, have come to be your mailman's lot. To date, Nature's elements have not stayed him from completing his appointed rounds, but sheer volume of the job has reached alarming proportions. It's a general condition—worldwide—and it has been going on for a long time.

More speed and efficiency in all operations are keys to a solution. Heavy contributors are modern transportation and bulk material handling. But the knottiest problems occur inside post offices where millions of letters must be sorted individually every day. Here, too, engineers aid the mailman with the newest equipment for . . .

MECHANIZED

MOST FAR-REACHING of government services, the Post Office Department counts its transactions in millions daily. New York City, alone, generates 8 to 10 million pieces of mail every day. Corresponding figures for Chicago and Los Angeles are 4 to 5 million and 3 to 4 million. In 1956, an estimated 48 *billion* pieces of letter-mail passed through the U. S. postal system. The trend continues upward —exponentially.

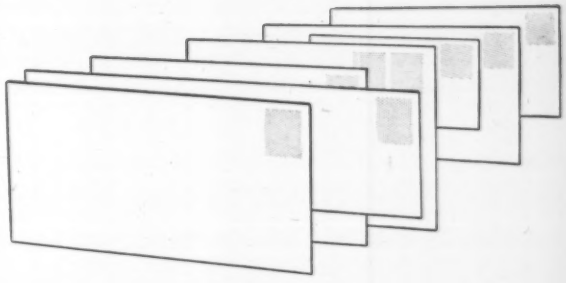
To manage this mountain of mail, the Post Office acknowledges that the day is long gone when manual methods were adequate. The speed of mail in transit has been stepped up by modern vehicles, and all kinds of machines now move mail in bulk. Individual pieces of mail present more stubborn problems, and today designers are hard at work to mechanize unit handling.

For this purpose, post office departments here and in other countries have set up their own engineering sections. In the U. S., work

Barrel culls letters from parcels

Separation of random mail into packages, long letters, and short letters is the job of this machine developed by the British Post Office. Carrier mail is conveyed into an inclined, rotating drum. As letters pass through the drum, they encounter hinged flaps which make up the drum periphery. Flaps permit the passage of short letters but long letters and parcels continue out the end of the drum.

MAIL HANDLING



at the Post Office Department's Office of Research and Engineering is supplemented by a Bureau of Standards project on mail mechanization.

OPERATIONS

Upon receipt in a post office, random mail is put through a number of operations most of which have always been done manually. This handling is the greatest consumer of time and manpower currently, and the present target of mechanization studies. In order of occurrence, the operations are: Culling, facing, stamp canceling, sorting.

Culling is the separation of random mail into general groups according to physical bulk. Characteristics of these groups are determined by the capacities and limitations of machines and equipment following the culling operation. Nearly universal is the separation of parcel post from flat mail at this stage. In further culling, flat mail may be divided into large and small letters according to overall dimensions. From the parcel mail, such items as rolled newspapers and magazines may be removed and treated separately if their volume warrants.

Facing is the orientation and arrangement of all pieces in one group so that stamps are all in the same position.

Stamp canceling is expedited by the preceding facing. Stacks of flat mail are fed into mechanical canceling machines. In cases where feeding is manual, output of the canceling operation is limited correspondingly.

Sorting is the distribution of canceled mail into pouches, pigeonholes, and the like, according to destination. Mail may be sorted many times before it reaches its destination. Often, multiple sortings, progressively refined, occur in the same post office.

TECHNIQUES

The objective of the engineering studies on mail mechanization is to displace clerical operations. These consist of three functions: *Transmitting* pieces of mail from one place to another; *reading* addresses or instructions; and *acting* on the information read. Typical actions are selecting, comparing, sorting, and recording. To be completely automatic, a machine substituted for an operation must perform all functions and actions which comprise the operation. Although this may be possible to only a limited extent, development of a machine may still be justified by increased output from the operation.

Generally, machines built and building perform only one or two of the four basic postal operations (culling, facing, canceling, sorting). There are several reasons for this limitation. Machines to perform canceling—midway in the processing—are already far advanced and in daily operation. A machine

Stamps trigger their own cancellation

Looking for stamps, then canceling them, is the function of this machine recently tested by the British Post Office. It requires that stamps carry an electrically conductive ink. The machine delivers the canceled letters in separate piles according to the corner in which stamps are found. The conductive ink is a graphite-base fluid called Napthadag. It is applied to the rear surface of stamps under the adhesive. It is harmless to humans, should they lick through the adhesive.

to do all four might be inflexible, therefore not adaptable to the variety and changes of conditions found in thousands of different post offices.

A machine substituted for a transmitting or acting operation is essentially a materials handler. Examples abound in almost any machinery field. Machines to perform sorting must include mechanical readers—less common, more sophisticated.

To enable mechanical reading, information must be converted into machine language such as punched cards or imprinted marks. Marks, in turn, function by contrast, conductivity, magnetism, fluorescence, or luminescence. U. S. preference is for machines that employ mark-sensing devices rather than punched cards. In the NBS equipment, information is coded in a dot pattern. Destinations receiving the greatest volumes of mail will have the simplest patterns, that is, the shortest abbreviations.

An advantage of standardized coded markings is that businesses can be expected to precode their mail, thereby bypassing post office encoders and in this way expediting sorting. Basis for optimism is the general acceptance of the present postal zone system. Researchers agree, however, that only humans —and sometimes not even they— will be able to read and encode the handwritten scrawlings dumped continuously into the postal system.

EQUIPMENT

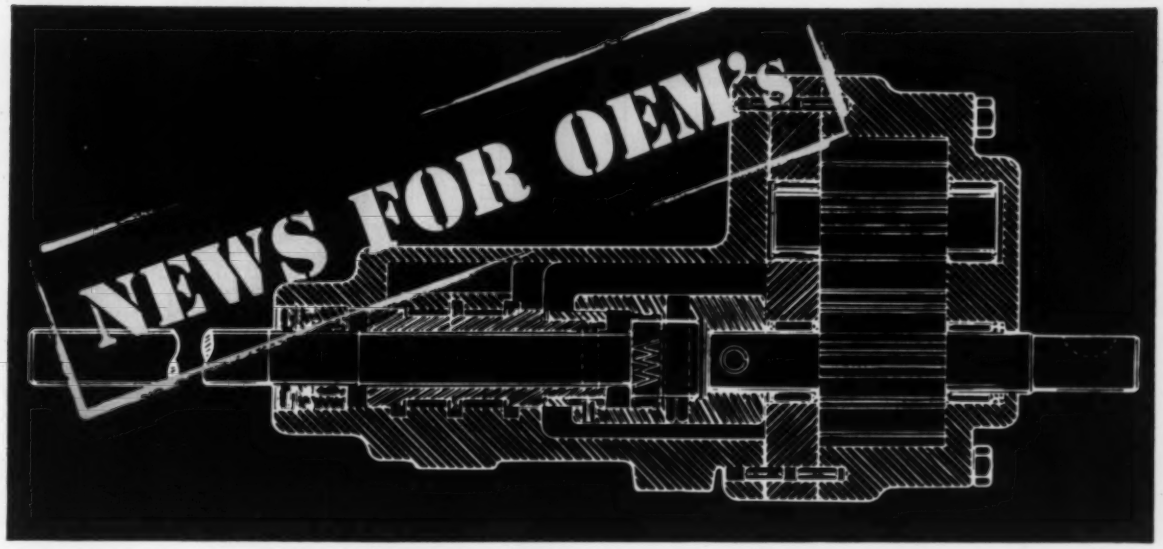
Culling, facing, canceling: Experimental machines for performing initial operations are currently installed in certain post offices throughout the country. Random collection mail is emptied from bags into a hopper from which both letters and packages are elevated by an endless belt. The mail is passed over five ports which separate packages from flat mail. The ports also separate flat mail more than 6 in. high from smaller letters.

Small letters pass into a vertical stacker from which they are fed to a scanning station. The scanner searches for stamps along one edge of the letters. Upon finding stamps, it signals the canceling machine accordingly. Letters that have not tripped the scanner are turned around and sent through a second scanner, thence into another canceling machine. All letters emerge canceled and oriented with stamps in the same corner.

Parcel sorting: More so than in the case of flat mail, parcel post sorting has been a laborious operation. From waist-high tables, each parcel clerk has performed 12 to 18 separations. New equipment to mechanize this job is the Greller semi-automatic parcel sorting system. One installation is in the Baltimore Parcel Post Station. It makes 21 separations at the rate of 12,000 parcels per hour, requires twelve men at peak production.

Initially, men read addresses, then code parcels and pass them to conveyor belts. As parcels approach a conveyor, an operator reads the codes, punches corresponding keys that activate any of 21 mechanical diverters down the belt. Signals for the diverters are carried on magnetic tape. Before reaching diverters, parcels are measured by an electric eye. This determines the number of deflecting paddles dropped at the diverter station. Long parcels require several paddles.

Mail sorting: Currently in use in European countries is the Transorma semi-automatic letter sorting machine made in Holland. Transorma is entirely mechanical in operation. One model, the first in the U. S., is installed at Silver Spring, Md. The British Post Office has de-



Behlen

NOW! *Expanded production makes* HYDRAULIC SERVO MECHANISM

available to MORE original equipment manufacturers

Originally known as the Behlen Powr-Steer, this advanced rotary type hydraulic servo mechanism has proved highly successful on thousands of farm tractors of many models and makes. Behlen was first to offer power steering for row crop tractors, five years ago. For the past two years, Powr-Steer has been used on a leading farm tractor line as original equipment. Demand soon outstripped our production capacity.

Now Behlen production facilities have been expanded to the point where we can offer our Hydraulic Servo Mechanism to a wide field of manufacturers of industrial heavy construction and agricultural equipment. From tractors to earth-movers. From fork-lift trucks to power shovels — every type of equipment where manual labor needs to be reduced.

In supplying the hydraulic "muscle" of Behlen's servo mechanism to your product, you will add magic to its sales appeal.

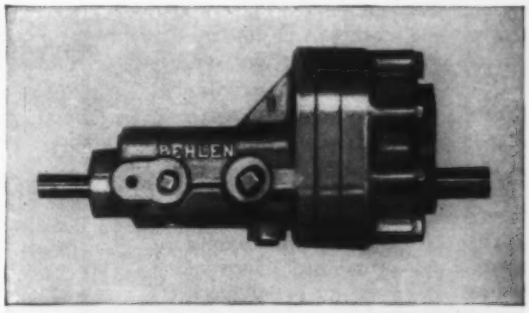
We invite you to see how easily the Behlen Hydraulic Servo Mechanism can be applied to your products as original equipment (or as extra equipment readily installed in the field). Your request (which will not obligate you in any way) will receive the personal attention of our production manager, Howard Christenson.

Phone, write or wire

BEHLEN MANUFACTURING COMPANY

Dept. DM-5 Columbus, Nebraska

World's largest manufacturer of tractor and grader power steering



The Behlen Hydraulic Servo Mechanism, Rotary Type, Series 2000, can be used for power steering or wherever a rotary servo motion is required. Controller and actuating parts are in one compact unit, for economy and simple installation.

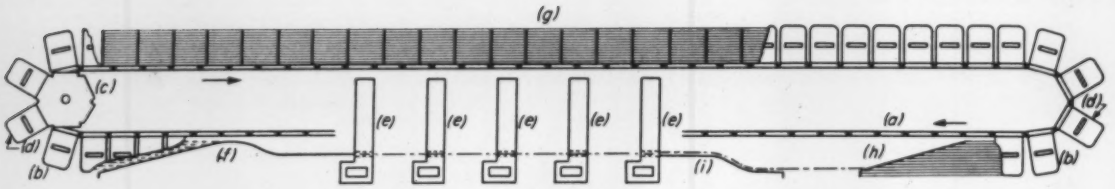
FULL 360° OPERATION

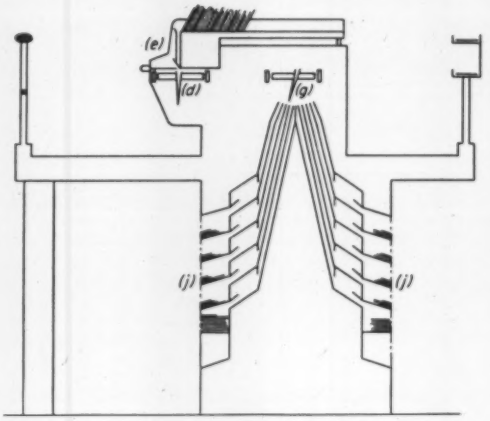
The Behlen unit is a gear-type hydraulic mechanism (in contrast to the piston type on passenger cars and other equipment). The power source in the unit is a gear motor that will provide continuous 360° turning under full power in either direction.

The power unit is mounted anywhere along the steering shaft. While the Powr-Steer operates as a servo mechanism between steering source and wheels, it also blocks and controls wheel shocks. Does not affect steering ratio. Maintains full and positive control through mechanical linkage in event of hydraulic power failure.

Specialized engineers in our Hydraulic Division are ready to adapt Powr-Steer to your specific needs in any of hundreds of machinery and equipment applications.

Circle 414 on Page 19





Pin patterns sort letters in Dutch machine

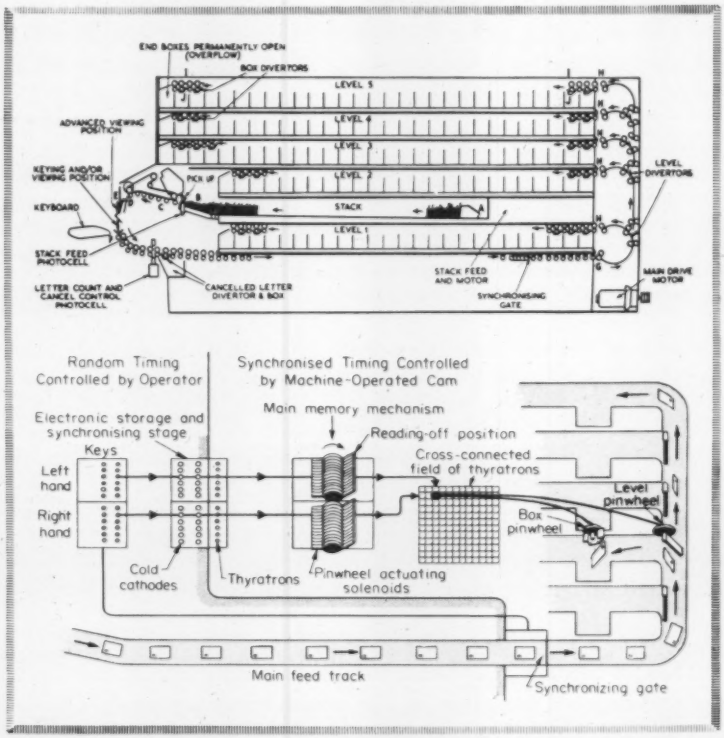
In the Transorma sorting machine, letters in trays are presented one at a time to clerks at coding keyboards *e*. Punching destinations into keyboards drops letters into pockets *d* and sets distinctive patterns of pins on corresponding carriers *b* by means of inclination device *f*. Matching pin patterns, as in pin-tumbler locks, cause delivery at proper chutes *g* and receptacles *j*. Endless chain *a* driven by sprocket *c* carries letters to destinations. After delivery, pin patterns are cleared by reset devices *h* and *i*. Machine has 300 letter receptacles in vertical rows of five each. Floor space occupied is 6 ft by 38 ft.

veloped its own letter sorting machine, which has electronic features.

Success with a laboratory prototype sorting machine for the U. S. system was announced just last month. The machine was developed by Rabinow Engineering Co. under Post Office Department contract supervised by National Bureau of Standards. It sorts letters at the rate of 36,000 per hour. Modular design permits combinations of units to meet varied mail traffic throughout the country. Controls are electronic, manual, or combined electronic-manual. Contract for a 1000-pocket production model has been let.

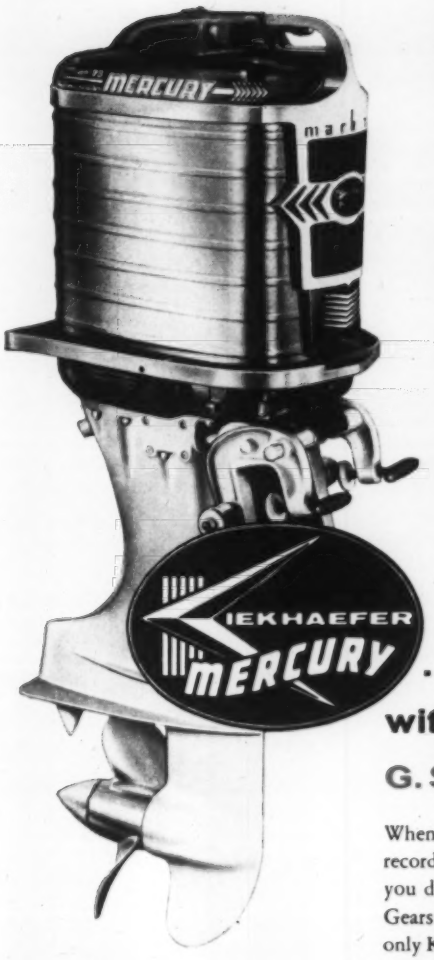
In the new American machine, a number of pockets on an endless conveyor carry letters individually to destination slots. Each pocket has a steel rod which carries twelve nylon wheels. Each wheel is shifted laterally on the rod into one of two positions. Codes assigned to the letters determine the wheel position patterns. There are 4096 total possible. The wheels drop into depressions having the same pattern, thus release letters into destination slots.

Faced mail to be sorted is delivered mechanically to clerks at reading and coding positions. The operators type abbreviated destinations on the backs of the envelopes. The extent of abbreviation



Electronic memory follows letters to slots

Letter sorting machine developed by the British General Post Office enables 144 separations at about 60 per minute. Letters are faced to an operator at a panel of 24 keys—12 left, 12 right. Depressing keys in a two-character code causes selection of level diverters and box diverters, starts letters down feed track. Selections are stored as pin settings in memory unit and synchronized with corresponding letters as they approach tiered boxes.



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When you make the kind of outboards that set new world's endurance records (as Kiekhaefer Corporation's famous "Mercurys" have done), you don't settle for anything but the best when it comes to specifying Gears and Pinions. And "the best" means G.S., in the experience of not only Kiekhaefer but of leading manufacturers in all divisions of industry.

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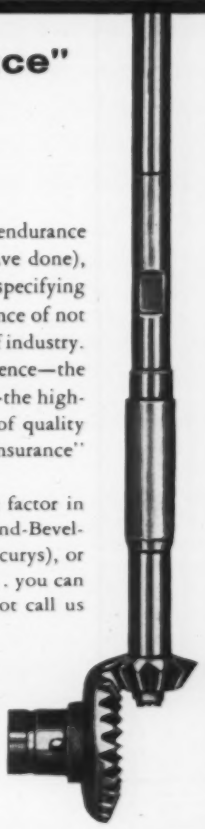
If efficient, failure-free power transmission is an important factor in *your* product . . . and whether you require a king-size Pinion-and-Bevel-Gear (like this one used in the "twice 'round the world" Mercurys), or some other form of precision-produced Gearing of any size . . . you can profit by making G.S. a partner in your production. Why not call us in for consultation on your needs—now?



SEND FOR *G.S. technical data, free! See where and how we mass-manufacture Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

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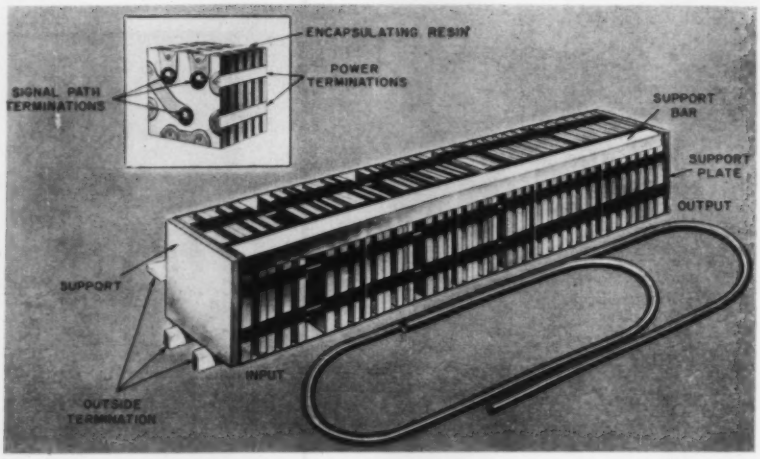
depends on the direction of mail flow (incoming, outgoing), volume of traffic to destinations, and local postal schemes. The typed impressions are in binary form, six bits for each alphanumeric character.

Mail thus imprinted then passes mechanically to a directory unit which automatically looks up codes corresponding to the dot impressions. The directory sets the wheel patterns on the individual letter pouches. In present form the directory can accommodate a city of 100,000 to 200,000. Use of a directory makes the machine flexible and adaptable. Directory changes can be made without mechanical changes elsewhere in the machine. Complete new directories can be installed easily.

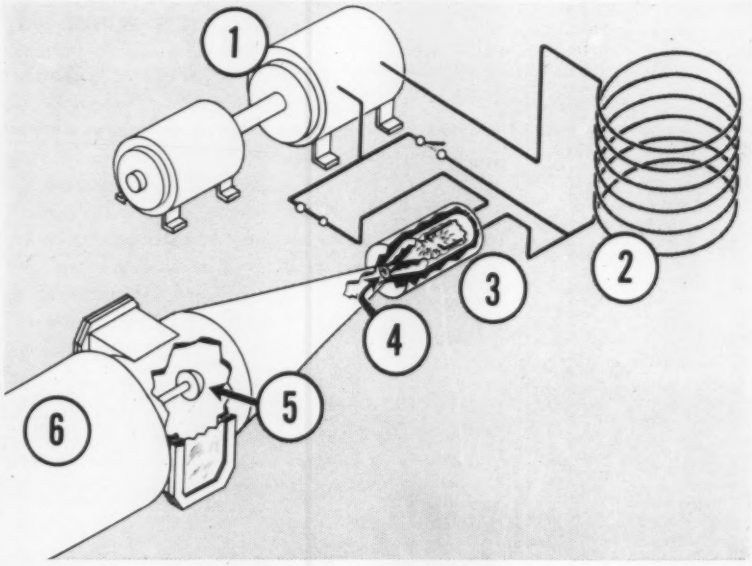
Machines described here, both American and foreign, may seem adequate for their jobs, but there's no such thing as "ultimate." Even now, engineers seek to mechanize the only function in the most advanced machines still done by humans. Intelligent Machines Research Corp. is developing equipment to read addresses prepared by any typewriter or imprinter. The sensing system will use the length and location of character strokes. But we wonder how it will handle misspellings. There'll always be a mailman!—S. R. GRIFFITH

Turbine-powered crawler tractor, built by Allis-Chalmers for research purposes, uses a Boeing gas-turbine power unit in place of the conventional diesel. Low-speed, high-torque characteristics of the turbine provide a built-in torque converter and net horsepower is said to equal that of the diesel counterpart. Little change in external appearance is noted. Exhaust gases have posed no operating problem and noise level is reported equal to that of diesel units.

Portable transistor TV sets, battery powered, will be marketed in the near future. Westinghouse has a laboratory model that uses 23 transistors; operates on house current, car batteries, or, for 10 hours, on its own rechargeable batteries. Batteries can be recharged by connecting the set to house current.



MICROMODULE five-stage receiver is shown in relation to a paper clip. Miniaturization achievement of Radio Corp. of America will provide the Army with a radically new production capability. Engineers believe that through use of the new circuit system a typical missile guidance and control unit could be reduced to one-tenth its present bulk and weight. Typical module (inset) is made up of individual elements or parts placed on ceramic sheets in the form of wafers. Each wafer is 0.3 in. square and several thousandths of an inch thick. Wafers are stacked in assemblies to make modules of the required electronic characteristics.



HOTSHOT II, new 50-in. diameter tunnel at the Gas Dynamics Facility of the Air Force Arnold Engineering Development Center, has already produced speeds above 32,000 mph although still undergoing calibration and shakedown runs. For comparison, velocity to escape earth's gravitation is 25,200 mph. Tunnel's essential elements include unipolar generator, 1, which feeds electric current to inductive storage coil, 2. Circuit in arc chamber, 3, is closed while magnetic field builds up. At desired energy level, switch is pulled. Arc thus produced heats chamber air over 40,000 F, causes pressure more than 30,000 psi. Plastic seal, 4, vaporizes and air flows through nozzle into test chamber, 5, thence to vacuum chamber, 6. Unique unipolar generator by Allis-Chalmers, Milwaukee, substitutes metallic fluid lighter than water for carbon brushes. Rated 6000 kw, its efficiency is over 98 per cent at 3600 rpm.

New high-torque low-current DC motor covers extended range of output speeds

The new Cramer Type 800 direct current motor offers an unusually wide range of output speeds, coupled with low current drain, high torque, high efficiency, and excellent speed stability. These features make it the ideal choice for timing devices, remote control equipment, recorders, signalling equipment, communications gear, displays, flashers, chart transports, and many other products.

Type 800 DC motor with standard gear train — shown 50% oversize

Wide Performance Range

Depending on requirements of speed, torque, and voltage, the rotor is wound to produce a basic motor speed of 960 to 3000 rpm. A gear train then reduces this to the speed required at the output shaft. Low rotor speeds result in lower current drain at all speed-torque combinations, but limit the torque available at the higher output speeds. Higher rotor speeds require a somewhat higher input current, but greatly increase the torque available at the higher output speeds.

The Table at lower right illustrates this flexibility of design, with a few examples from the virtually unlimited range of performance characteristics which it provides. Where very low input current is required, and the supply voltage does not exceed 12 volts, the use of the low-speed rotor will provide 30 oz. in. at speeds below 3 rpm and 0.5 oz. in. at 200 rpm. The higher speed rotors meet the requirements of higher input voltages, and provide greatly increased torque at the higher output speeds with only a moderate increase in current drain. The high-torque motor has the additional advantage of speed stability within 10% from no-load to full-load, at speeds below 5 rpm.

The examples given in the Table are for illustration only. By correct choice of rotor winding and gear ratio, an unlimited number of operating specifications can be established throughout the entire range shown. The motor is also available without gear train, for output torques of 0.1 to 0.6 oz. in. at speeds up to 3000 rpm.

OUTPUT SPEEDS WITH GEAR TRAINS	960 RPM ROTOR LOW INPUT CURRENT *(3 to 12 volts DC)*		3000 RPM ROTOR HIGH OUTPUT TORQUE *(3 to 30 volts DC)*	
	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.
2 rpd	.16	30	.....	.....
1/6 rpm	.16	30	.56	30
3 rpm	.35	24	.64	30
10 rpm	.35	8.5	1.04	30
30 rpm	.35	3.0	1.72	21
60 rpm	.35	1.5	1.72	12
80 rpm	.35	1.1	1.72	8.5
200 rpm	.35	.5	1.72	3.5
900 rpm	.....	.....	1.90	.8

Typical Performance of Type 800 DC Motors for Minimum Input Current or Maximum Output Torque

Specifications

SPEEDS — 2 rpd to 900 rpm with gear train, 960 rpm to 3000 rpm without gear train.

TORQUE — 0.1 to 0.6 oz. in. without gear train, and to 30 oz. in. with gear train.

CURRENT DRAIN — as low as 30 milliamperes, depending on voltage, load and speed.

VOLTAGES — from 3 to 30 volts DC.

REVERSING OPERATION — with negligible speed difference, because of special motor design.

GEARS — precision-hobbed throughout, totally enclosed and with sealed-in lubricant.

For your free copy of informative Bulletin PB-800, write:

CRAMER CONTROLS
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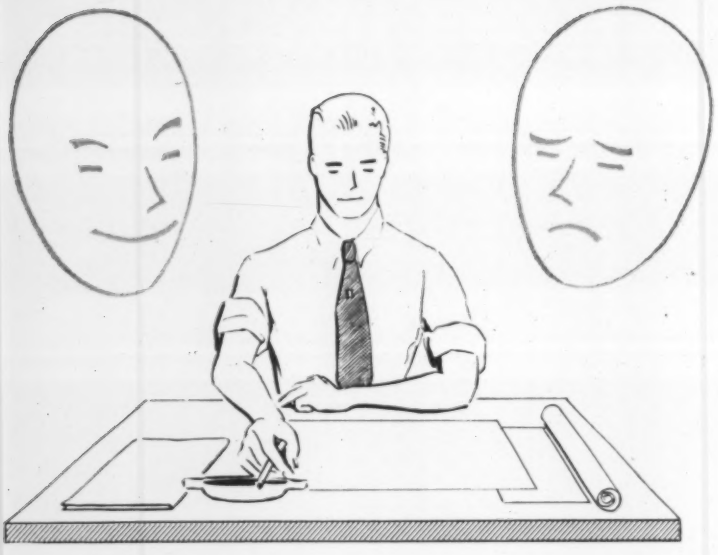

Personnel

How

PERSONNEL administration practices and techniques for engineers have, in many companies, advanced with growing dependence on their engineers. In other companies, personnel practices have undergone no change—as the companies grew and their engineering departments expanded, the responsibility for administering engineers remained vested in the personnel department. The same policies, criteria, and practices were applied to engineers as were used for dealing with nonprofessional employees.

As shown by the survey, *Engineering Manpower: How To Increase Its Productivity*,* on which this series of articles is based, the importance of personnel policies is not to be denied. They vitally affect the engineer by their influence on his relationship with the company, his salary and advancement, training, job security, and integration with management. They greatly determine his job satisfaction and his personal motivation.

Why special policies

The problem of personnel policies for engineers was discussed with executives of a number of companies, in which the size and importance of the engineering department have increased substantially within the last two decades. Executives were asked if increased numbers of engineers have resulted in or required modifications of their personnel administration program.

Of the group, 50 per cent reported that personnel administration in the engineering field demands continued attention to new and better techniques for handling engineers' special needs and requirements. Thirty per cent contended that, although their personnel administration had always been good, they had been unable to do as much as they would have liked to meet the special needs of the engineer. Twenty per cent of those interviewed reported that increased numbers of engineers required no new administrative techniques because, they contended, engineers are no different from other employees.

As these samples indicate, management's attitude on this question varies considerably. The survey showed that the larger and older corporations generally felt that engineers require special personnel handling.

Not content with traditional personnel practices, a number of companies have created separate engineering personnel departments. They report considerably more success in dealing with engineers than the regular personnel departments, largely because they handle the engineers' problems more quickly and with greater understanding.

Engineers often experience a need for well-considered personnel policies tailored to their specific efforts. Structural engineer W. W. Griffin Jr. has expressed it:

> • In dealing with engineers in great numbers, the personnel departments of large corporations often have lost sight of them as individuals and treated them, to use a phrase I have stolen, as "depersonalized units of mass administration."

Such dissatisfactions as poor communications and loss of identity with management, along with compensation considerations, have caused some engineers to resort to collective bargaining in an attempt to restore their status. The situation offers an ironic aspect; engineers resorting to collective bargaining in an attempt to regain their professional standing. Yet they have felt powerless to react in any other way and have seen production workers force their demands on management by this method.

Appraising the engineer

Many of the companies contacted had systems for periodically review-

*©1957, G. A. von Peterffy

Administration

Companies Treat Their Engineers

ing their engineers, ranging, as might be expected, from the very informal to the complex. Usually, the engineer is reviewed by his immediate supervisor, who ranks him against a set of qualifications, or else ranks one engineer against another in terms of contributions to the department.

Administering such review systems can lead to sticky problems. Whether the personnel department or the engineering department should control the interviews has been the cause of major controversies and misunderstandings. When the personnel department controls the system, the engineer resents the nontechnical approach. A more technical approach, however, would necessarily utilize lower level supervisors, many of whom are unskilled at personnel evaluation.

Several of the companies contacted admitted they were faced with this problem. In their opinion, the solution lies either in forming a separate personnel department "of engineers for engineers" or in conducting an extensive training program which would equip engineering supervisors to review competently and thus keep the program within the department.

Many companies have termed evaluation of engineers a valuable but sensitive part of the review system. "Unless this is handled skillfully," one executive said, "a lot of

Checkpoints for Engineering Management

- ☑ **1. Does your company appraise engineers as professionals whose personal efforts determine the company's technological position?**
- ☑ **2. If your company appreciates the need for implementing special personnel techniques for engineers, has it taken any definite steps in this direction?**
- ☑ **3. If no special steps have been taken, do engineers complain they have lost identity with management . . . have lost their professional status . . . have lost individualism?**
- ☑ **4. If the personnel department administers your periodic appraisal system for engineers, would the company gain if the engineering department administered the system instead?**
- ☑ **5. Have you seriously considered retaining part-time or other working connections with engineers who reach retirement age?**

animosity can be created." Handling the interview requires a great deal of skill on the part of the supervisor. Often an engineer will assume a defensive attitude and take exception to the supervisor's comments. At other times, the relationship between supervisor and engineer has been so close as to make the interview a source of painful embarrassment to both of them. Because criticism is hard to sell, some companies prefer to have their personnel departments handle this function since normally they have more skill in interviewing. But this too often degenerates into perfunctory performance of a routine function and eventually causes resentment among engineers.

Job titles

Several large firms reported that job titles help an engineer to establish his position within the department. Usually there were large salary differences between engineers and yet there were no title distinctions to indicate the various grades of responsibilities. An airframe manufacturer reported attempting to develop meaningful job titles so that engineers could readily "locate" themselves within the department.

Retirement

Often discussed during the course of the survey was the question of engineers' retirement. More than one engineer interviewed offered caustic comment on the effects of compulsory retirement for experienced engineers.

Most of the companies contacted enforce retirement of engineers. Only about 10 per cent of those companies permitted engineers who had passed retirement age to remain at work full-time. Some companies retained the services of such men by hiring them back as consultants or part-time advisors, but the dominant feeling among executives is that compulsory retirement is desirable because it keeps the promotional ladder open for younger men. And yet, more and more companies are coming to use retired engineers on a consulting basis.

One reaction to retirement has been the move on the part of some retired engineers to set up engineering consultant firms of their own. The survey noted three such organizations in active operation.

There is little room for doubt, however, that much valuable engineering experience is lost because of compulsory retirement practices.

Next article in this series will appear in the May 29 issue. It will deal with compensation for engineers, and discuss salary administration.

Recommendations for Management

1. Check Personnel Administration

Where engineers have been administered by personnel departments, who evolved policies no different from those for nonprofessional employees, there have usually been discord, unrest, and in some cases, unionism among engineers. Effective personnel administration can have profound effects on the relationship between engineer and company.

2. Use Engineering Supervisors

When delegating personnel administration, evaluation, and promotion authority, favor engineering supervisors over general personnel people insofar as the supervisors' competence permits. In general, the engineer is more familiar with his supervisors and feels, in his own mind, they are better qualified to pass on his special needs and problems.

3. Watch Salary Administration

Permit engineering management to exercise responsibility in the area of salary administration for engineers under their jurisdiction. This serves also to distinguish the engineer's relationship with the company.

4. Let Personnel Control

When delegating personnel and salary administration authority to the engineering department, don't overlook the personnel department. Permit them to co-ordinate and control these administration functions to ensure that they are being realistically carried out.

5. Retain Older Engineers

Keeping company connections with older engineers who are eligible for retirement and who wish to remain on the payroll is an excellent way to enjoy the benefit of valuable experience. It is recommended, however, that they be retained only on a part-time basis or as consultants. Permitting them to remain in senior positions of responsibility may have serious repercussions on the morale and motivation of younger men.

All-in-one selector switch—indicating light by Westinghouse.

A start button, a stop button, an indicating light—all in one handsome, compact selector unit.

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Saves considerable initial expense!

They're oil-tight, of course—with a panel-enhancing chrome finish—a lifetime operation snap-acting switch—and interchangeable nameplates for on-off, start-stop, forward-reverse. Or any combination you choose.

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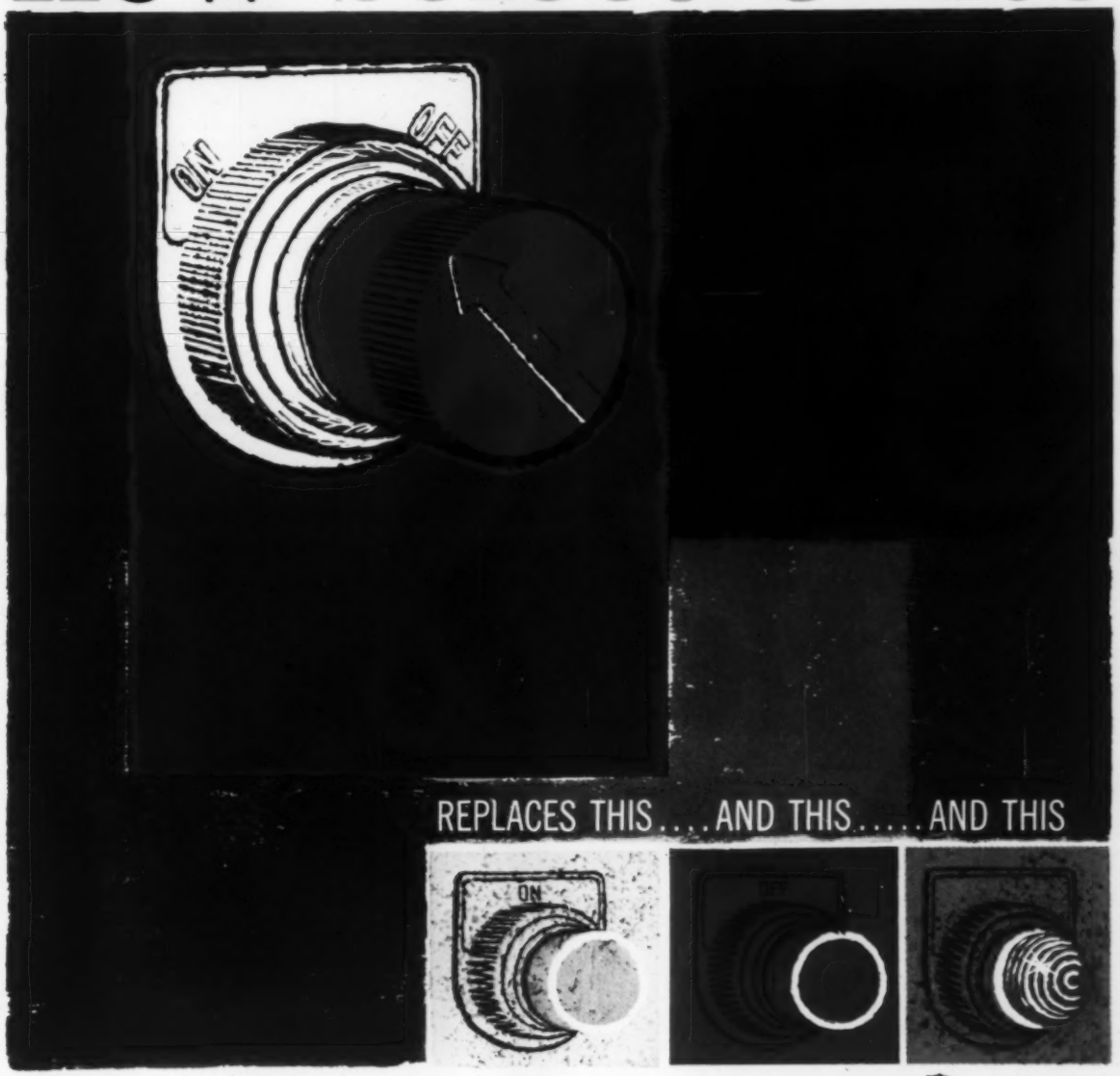

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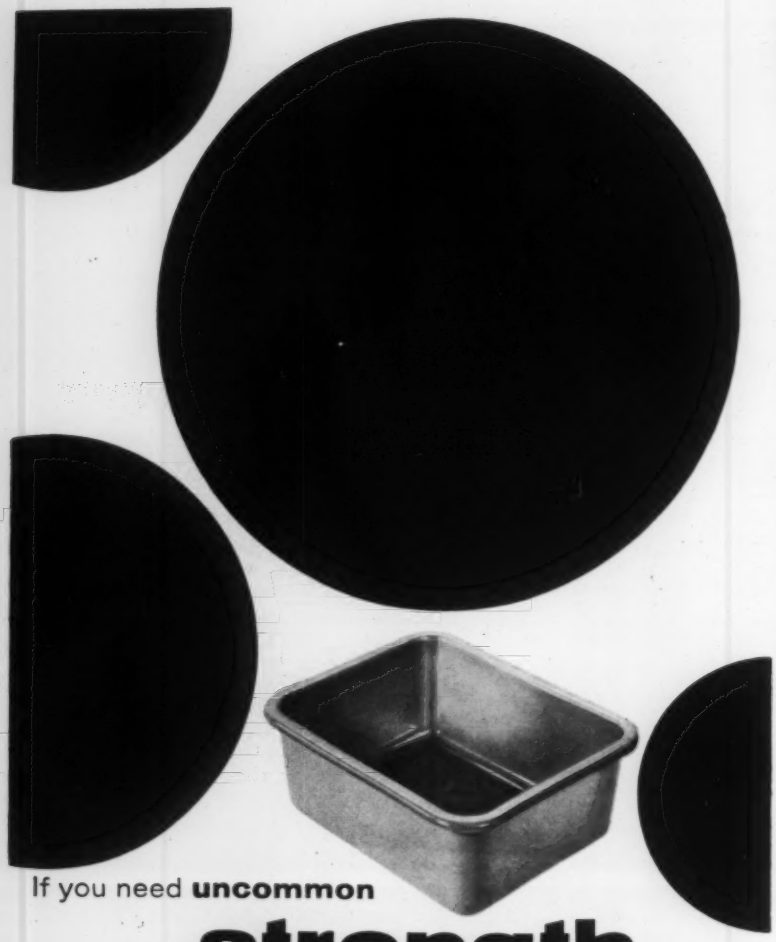

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This colorful dish pan, for example, is tough and rigid, can hold boiling water, will not warp, resists detergents and bleaches, and keeps its high gloss and attractiveness.

This same plastic makes crisper-trays, food containers and tumblers that never turn brittle, never shatter when frozen, and are easily cleaned.

These very qualities of durability recommend GREX for a limitless variety of uses: refrigerator parts that stand up under heavy loads and cold temperatures; sterilizable bottles; canisters and cups that don't break; automotive parts . . . toys . . . furniture drawers. You name it, and we'll show how *this versatile plastic means better products for you.*

*Trademark for W. R. Grace & Co.'s polyolefins. W. R. Grace & Co. produces GREX resin for a wide variety of uses, does not make the finished articles mentioned above.

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GREX* in action

That dishpan on the left was molded from GREX high density polyethylene by an important new process . . . a Pre-Compressed Molding process which gives highly superior products, substantial dollar savings, and greater economy of operation.

Pre-Compressed Molding

In this new molding process, the gates contain valves that are closed as the injection takes place, and the material in the heating chamber, runners and sprues is compressed to the maximum pressure for molding. At optimum pressure, the valves are automatically opened and the plastic material pours into the cavity at high velocity. The valves are then closed and the finished part is ejected without sprues or gates—another plus feature. Multiple or single cavity molds may be valve-gated as well as individual runners in molds with an unusually large number of cavities.

It makes possible bigger, deeper molds and produces strain-free moldings with greatly improved physical properties, particularly in impact strength. Parts are freer from stresses, poor welds, trapped air and cracks . . . surface finish on parts noticeably improved.

Scrap losses are decreased. Because no gates or sprues need be trimmed, finishing cost are reduced. With lower machine temperature, warpage, material breakdown, shrinkage marks and color variations are virtually eliminated for all thermoplastic materials.

Since GREX high density polyethylene is suitable for elevated temperature applications and can be boiled and sterilized, it is particularly important that moldings be strain free and warpage be minimized. This new process almost invariably reduces molding cycle time for GREX and other thermoplastics—usually one-half to two thirds!

Putting this Process to Work for You

GRACE's Polymer Chemicals Division has been licensed exclusively under patents held by Columbus Plastic Products, Inc., Columbus, Ohio, and in turn GRACE will sub-license plastic molders so that the benefits of this new process may be made widely available.

For more information write for your copy of "The Story of Pre-Compressed Molding."

Atom Admiral Blasts "Empire Builders"

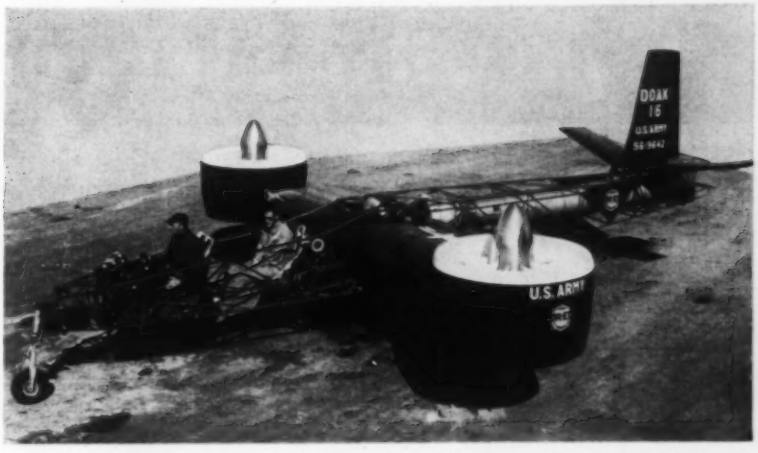
Says Superefficient Manager And "Eggheads" Don't Mix

BROOKLYN, N. Y.—Size always endangers quality. Be careful of applying "business methods" to every human occupation because a businesslike attitude makes for efficiency only in routine matters. It is disastrous when applied to creative people. "Nobody can waste as much time as a superefficient administrator trying to run a group of 'eggheads,'" said Rear Admiral H. G. Rickover, chief of the Naval Reactors Branch, speaking at building dedication ceremonies recently held at Brooklyn Polytechnic Institute.

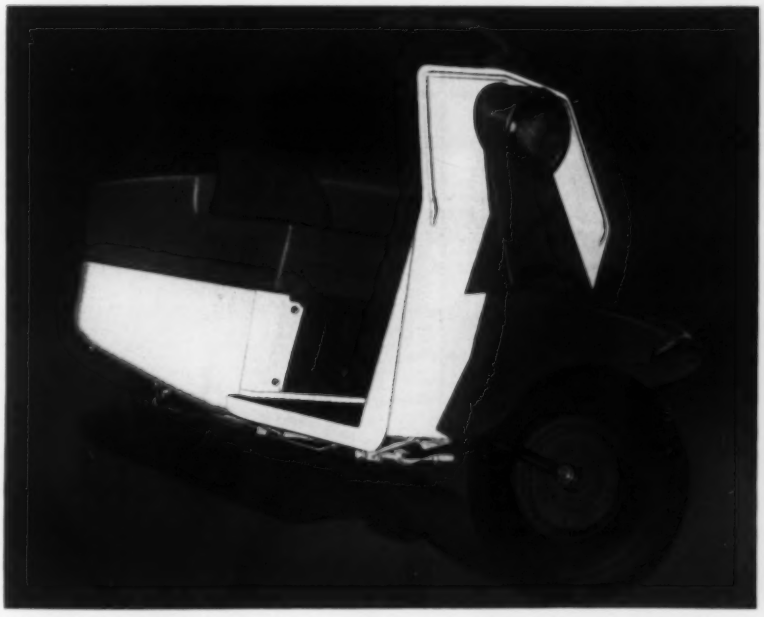
Said Rickover, "In any sizable organization there must be some people who merely maintain the proper environment in which productive work can proceed smoothly. They tend the physical plant and handle personnel matters — their talents are in housekeeping and administration, and their function is, or ought to be, entirely subordinate to that of the productive workers whose labors alone justify existence of the organization."

Whoever has had anything to do with organizations, he pointed out, will have observed the administrator trying to gain control over the whole corporate body. But, contended Rickover, the success of any organization can be measured accurately by the relative position of administrators to productive workers. Successful organizations get along with a minimum of administrators; organizations whose real work is declining almost always have swollen managerial staffs. Administrators, he said, are natural boosters for size because of their natural desire to enhance their own importance.

"The role of the administrator is of necessity less important where creative intellectual work is done than where the work is routine," Adm. Rickover said. "Few administrators possess the capacity to master the special fields in which creative brainworkers are expert; nor can they, as a rule, understand the mental processes of professional people and the atmosphere of intellectual freedom without which these people cannot work effectively. Without mastery of the subject and understanding of the people, there is little an administrator can contribute to improvement of the mental work done in his organization. Worse, he often becomes more of a hindrance than a help."



DOAK'S FLYING MACHINE shown here during ground tests is one of several Army-sponsored VTOL research vehicles (*Machine Design*, Mar. 20, 1958). Developed by Doak Aircraft Corp., the craft has ducted wingtip propellers that rotate 90 deg for vertical takeoff and horizontal flight. This provides an advantage over other VTOL designs: Doak can take off and land horizontally where airfields are available, which requires less power and increases fuel payload. Powerplant, running through rear fuselage, is a Lycoming shaft turbine engine.



MORE LIGHT AT NIGHT is the purpose of a new reflective finish developed by Minnesota Mining and Mfg. Co. Shown here in one of its first applications, Reflecto-Lite is available in a variety of colors, all of which reflect brilliantly at night in the headlights of other vehicles. Cushman Motors Co. has introduced the safety coating on its motor scooters. Two-tone pattern, above, outlines scooter dimensions both day and night. Bicycle and automobile manufacturers may also use the new product.

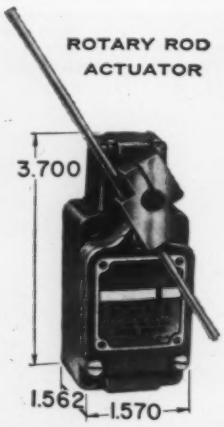
MICRO SWITCH Precision

...FIRST IN PRECISION SWITCHING

Two sound ways to

Compact "LS" Limit Switches are Available in 6 Different Actuator Designs

COIL-SPRING ACTUATOR



ROTARY ROD ACTUATOR

ROTARY ARM ACTUATOR

ROLLER PLUNGER ACTUATOR

PLUNGER (IN-LINE) ACTUATOR

ADJUSTABLE ROTARY ACTUATOR

These are small two-circuit, completely sealed limit switches. Their small size and versatility of mounting permits compact installation on all types of industrial machinery which require dependable long-life precision switch gear.

In this "LS" series there are six actuator designs. All rotary actuators are field adjustable to operate in clockwise direction, counter-clockwise, and in both directions—with operation point adjustable to any position thru 360 degrees. Their heads can be faced in any of four positions.

The ½"-N.P.T. internally tapped conduit opening is in the bottom of the housing. The replaceable basic switching unit within enclosure has No. 8 terminal screws.

COIL-SPRING ACTUATOR

Can be operated from any direction. Useful in foundry, conveyor and packaging operations.

ROTARY ROD ACTUATOR

Has extremely low force characteristics. Rod is adjustable to any length. Operating point and direction are adjustable. Excellent for use in counting and detecting applications.

ROTARY ARM ACTUATOR

The heavy duty forged aluminum arm actuator with roller is designed for cam and slide operation. Field adjustable operating point and direction. Its uses are unlimited.

ROLLER PLUNGER ACTUATOR

For slow-rise cams or slides, this actuator head can be rotated 90° for operation by cams whose approach is perpendicular to the mounting surface of the switch.

PLUNGER (IN-LINE) ACTUATOR

For use where the switch can be located so that the switch plunger motion is in line with the actuating device. Plunger has ¼ inch overtravel.

ADJUSTABLE ROTARY ACTUATOR

Roller lever arm length is adjustable to any point in a 2½ inch range. Head assembly can be positioned to any of 4 sides of switch. Actuating direction and operating point are adjustable.

For details as to electrical ratings, mechanical characteristics, adjustability, and other features on this series of limit switches, ask for Data Sheet 138 and Catalog 83 on enclosed switches.

Switches have uses unlimited

improve initial design

The New "E6" and "V6"... Easier Installation ... Better Sealing ... Improved Insulation

The new "E6" and "V6" series of small limit switches have many new and improved features over the design first introduced by MICRO SWITCH in 1939. This design is the smallest and most compact enclosed limit switch available for all industrial uses. This new series is interchangeable with the old series—same mounting holes, and same envelope (housing) dimensions.

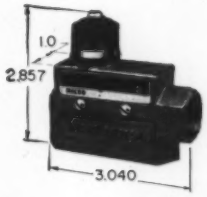
The new housing is divided into two parts with the terminal screws exposed. This saves wiring time.

The new one-piece elastomer combination insulator and seal is cemented into the bottom half of the switch assembly, replacing a separate gasket and wrap-around glass cloth insulator. This saves installation time and provides excellent insulation and sealing of the enclosure when assembled.

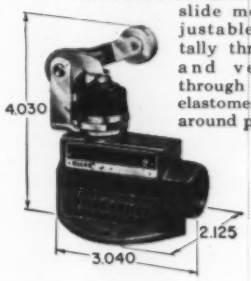
The new housings have heavier walls yet envelope (housing) dimensions are the same as the old design. Hexagonal conduit hub facilitates connecting of conduit.

Six different actuator types are available. All six are available in either side mounting (E6) or bottom mounting (V6) designs.

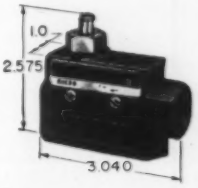
Ask for Data Sheet 145 and Catalog 83 for data on line of enclosed switches.



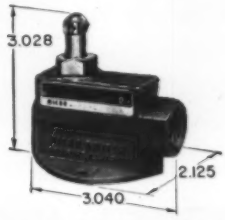
Actuator for straight, in-line operating motion with controlled overtravel. Elastomer seal boot around actuator protects against dirt and moisture.



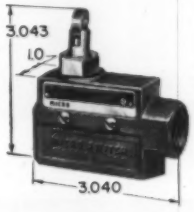
Roller lever actuator for cam or slide motion, adjustable horizontally through 360° and vertically through 225°. Has elastomer seal boot around plunger.



Plunger actuator for straight, in-line operating motion with controlled overtravel.



Roller plunger actuator for slow-rise cam or slide motion with controlled overtravel. Roller in line with case.



Roller plunger actuator for cam or slide motion with controlled overtravel. Roller at 90° angle to case.

Roller lever actuator for cam or slide motion, adjusttable horizontally through 360° and vertically through 225°.

MICRO SWITCH . . . Freeport, Illinois
A Division of Honeywell

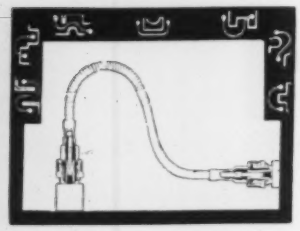
The two-word name MICRO SWITCH is NOT a generic term. It is the name of a division of Honeywell.

Honeywell

MICRO SWITCH PRECISION SWITCHES

(Advertisement)
FLEXIBLE SHAFTS

Handle wide variety of control applications.

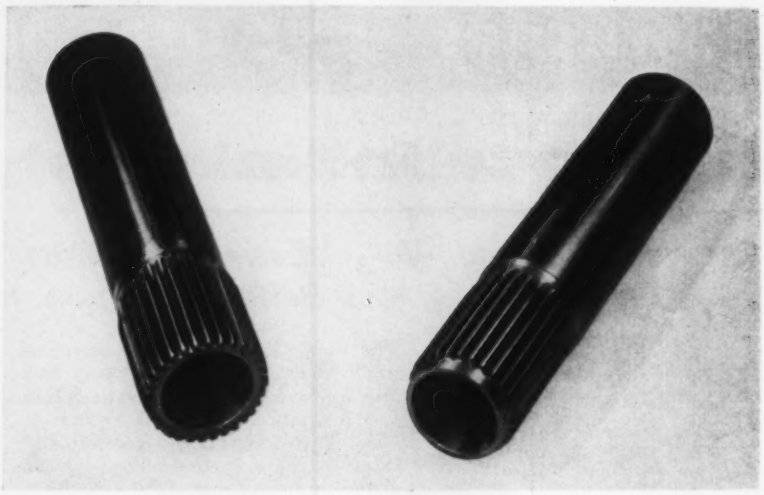


The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the power drive flexible shaft which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the remote control flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The remote control shaft provides for both rotation and reciprocation, such as the opening and closing of a valve.

● ● ● For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 420 on Page 19



COLD-ROLLED SPLINES on thin-walled tubing are formed with modified Roto-Flo equipment, the product of Michigan Tool Co., Detroit. Circular racks are reciprocated over the tubular parts in short, fast travel. Racks generate the same tooth form, for teeth having either a 30 or 45-deg pitch angle, as would be produced by hobbing action. Pressure applied is low—3000 to 4000 lb. Rack line of action is stationary, while workpieces are moved on their own axes at rates of 1/16 to 1/8 ips. Mandrel headstock center is used when rolling thin-wall tubes. In such cases, parts may have as little as 0.075 in. from root of the tooth to the ID of the tube. This method permits rolling of splines on undercut parts. For parts having shoulders, the rack can be notched so that full-depth teeth can be formed to within 1/4 in. of the shoulder. As wear occurs in the rack, it is rotated to bring unworn portion of the forming teeth into use.

Gives Six-Point Approach To Evaluating R & D Efforts

Scientist Notes Management's New Interest in Research

ROCHESTER, N. Y.—A six-point approach to evaluating research and development programs was outlined before the Tenth Annual Management Conference, held recently at Cornell University. Dr. John A. Leermakers, assistant director of Kodak Research Laboratories, pointed to a "more direct interest" on the part of management in today's research.

Because it has established working principles and practices for the traditional business operations, he said, management is now seeking equally sound practices for controlling the research and development functions. And yet, Dr. Leermakers said, a single system for evaluating both research and development cannot be applicable to exploratory research. "Some of the most successful projects from a commercial standpoint cost relatively little; others on which large sums of money are spent never lead to a profitable product."

As an approach to over-all evaluation, he suggested a set of ground rules that might be applied to assessing research and development results:

1. Evaluation should be on the basis of clearly assigned responsibility. "Management must make it clear what it expects of the laboratory," he said.
2. The system of evaluation should be agreed upon as realistic and workable by both management and the research director.
3. Evaluation should be followed by action, but this action need not always be abrupt.
4. Evaluation should be done on a continuing basis.
5. Evaluation should accommodate both long-range and short-range objectives.
6. Evaluation should consider the importance of intangible contributions.

He added, "Today, both manage-

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GOOD BUY: COPYFLEX!

■ Say good bye to aggravations and increasing costs for downtime and repairs for older reproduction equipment! Modern Copyflex gives you better results, faster, with less operator effort... pays for itself in no time at all!

Take Copyflex Model 575, shown here. With this advanced machine, you can boost your average operating speeds up to 250%. It offers a super-fast mechanical speed of up to 75 f.p.m. and a wide 46-inch printing width. The powerful two-stage exposure lamp can be operated at either 7,500 watts or 5,000 watts with a flick of a switch. A host of time-saving conveniences include: one-knob speed control with perfect automatic synchronization of print exposure and development, automatic separation of exposed prints from originals, automatic stacking of tracings and prints, front or rear delivery.

The Model 575 — like all Copyflex machines — gives you problem-free installations and operation. No exhaust venting, no plumbing, no auxiliary equipment.

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1800 Central Road, Mount Prospect, Ill.
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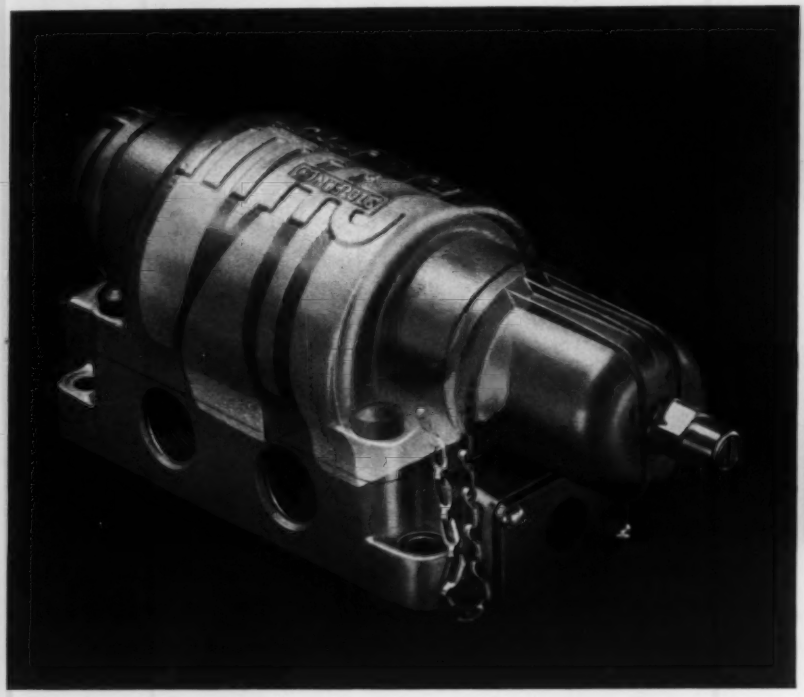
Introducing the revolutionary new MAC 4-way

DUAL-SPOOL

CIRCULAR-FLOW AIR VALVE



The MACsolenoid energizes the inner spool, releasing compressed air to activate the outer spool. There is no lag between spools. The shock load of the main spool is dissipated through rubber cushions.

The Dual-Spool's proved MACsolenoid has new instant plug-in wire lead connectors that are waterproof and vibration-proof. The solenoid and cover assembly detach in seconds without tools.

Features efficient spool-within-a-spool design...sells for about half the price of most other ½" to 1¼" valves... meets all J.I.C. specifications

MAC's new Dual-Spool air valves represent an entirely new principle in air valve design. They operate at speeds that meet any known requirement . . . with shorter stroke . . . direct operation . . . and a highly efficient *circular* air flow that provides full flow throughout rated capacities.

They operate on the *low current requirements of minimum amplified circuits* . . . needing just .8 amperes of inrush current and .125 amperes holding at 115 volts—60 cycles. The new Dual-Spool valves are compact, too . . . about one half the size of similar-use competitive valves (½" to 1¼") . . . and sell at about half the price in single- and double-solenoid models.

Fewer parts and simple design reduce maintenance. Integral conduit boxes connected by wiring channels permit optional wiring. Plug-in wire lead connectors speed up installation. The MACsolenoid—which operates up to 30 *million cycles* without appreciable wear—shaves replacement costs to a minimum.

4-way Dual-Spool air valves are now available in ½", ¾", 1" and 1¼" pipe sizes . . . are fully tested and guaranteed. Contact a MAC representative listed at the right or write direct for complete details.

Pat. applied for on all valve features ©MAC

MECHANICAL AIR CONTROLS, INC. MAC 10030 Capital, Oak Park, Detroit 37, Michigan

PHONE YOUR NEARBY "MAC" REPRESENTATIVE FOR DATA AND DELIVERY

ARKANSAS
Branch-Merwin Tool Specialists, 477 N. Bellevue, Memphis 5, Tenn., BRoadway 8-6102

CALIFORNIA
OAKLAND 8—The Rucker Co., 4700 San Pablo Ave., OLympic 3-5221
SOUTH GATE—The Rucker Co., 4956 Firestone Blvd., LOrain 4-2521

FLORIDA
MIAMI SPRINGS—Aero Hardware & Supply Inc., 4301 Northwest 36th St., TUxedo 8-2414

ILLINOIS AND IOWA
CHICAGO 6—Walter Norris Engineering Co., Civic Opera Bldg., 20 N. Wacker Dr., STate 2-2804

INDIANA
EVANSVILLE 14—Neff Engineering Co., 2509 Washington Ave., GReenleaf 7-4141
FORT WAYNE 3—Neff Engineering Co., Station A, P.O. Box 2001, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 2—Neff Engineering Co., 1955 Central Ave., WAlnut 5-5311
SOUTH BEND—Neff Engineering Co., 707 South Eddy St., ATlantic 7-5655

MARYLAND (and Dist. of Columbia)
BALTIMORE 18—N. B. Cochrane Co., 100 E. 20th St., HOpkins 7-4884

MASSACHUSETTS (and New England)
BOSTON 34—Electrical Apparatus Co., Inc., 1200 Soldiers Field Rd., STadium 2-7440

MICHIGAN
BAY CITY—Fred Kober, 506 So. Chilson St., TWinbrook 2-2629
FLINT 2—Kober Sales Engineering Co., 1115 Root St., CEdar 2-7165
WESTERN MICHIGAN—Everett Adams, 17212 Sharon Road, Chesaning, Michigan, VIctor 5-3446

MINNESOTA
MINNEAPOLIS 9—Air & Hydraulic Equipment Co., 15 E. 38th St., TAylor 3-6118

MISSISSIPPI
Branch-Merwin Tool Specialists, 477 N. Bellevue, Memphis 5, Tenn., BRoadway 8-6102

MISSOURI
ST. LOUIS COUNTY—Oscar E. Jost Co., P.O. Box 6, St. Ann, HArrison 8-4488

NEW JERSEY
(**NORTHERN**) Machinery & Machine Supplies Co., Inc., 305 East 47th St., New York 17, New York, PLaza 8-0744
(**SOUTHERN**) Automation Aides, 1618 Willow Ave., Philadelphia 26, LaMott, Pennsylvania, MElrose 5-5555

NEW YORK
BUFFALO 26—C. H. Tepas Co., 137 Lamarck Drive, CIrcle 3210
NEW YORK 17—Machinery & Machine Supplies Co., Inc., 305 East 47th Street, PLaza 8-0744

OHIO
CINCINNATI 2—Fluid Power Engineering Co., 205 Keith Bldg., MAin 1-6640
CLEVELAND 9 (PARMA)—Fluid Power Engineering Co., 5451 Broadview Rd., FLorida 1-1199

OREGON
PORTLAND—The Rucker Co., 911 N. W. Hoyt St., CApitol 3-0205

PENNSYLVANIA
PHILADELPHIA 26, LaMOTT—Automation Aides, 1618 Willow Ave., MElrose 5-5555
PITTSBURGH—Machinery & Machine Supplies Co., Inc., 1307 Rutherford St., LEhigh 1-1235

TENNESSEE
MEMPHIS 5—Branch-Merwin Tool Specialists, 477 N. Bellevue, BRoadway 8-6102

TEXAS
DALLAS 35—Womack Machine Supply Co., 2010 Shea Road, FLeetwood 7-3871

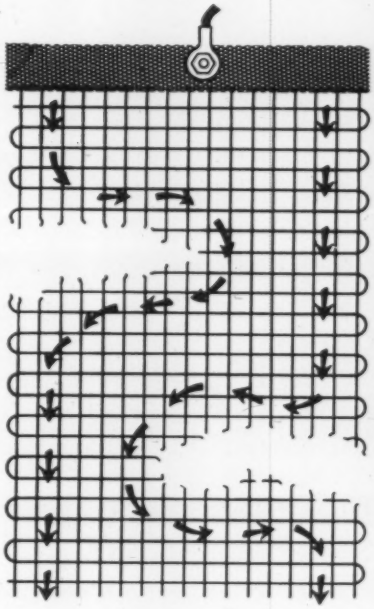
WASHINGTON
SEATTLE—The Rucker Co., 1000 4th Ave., South, MAin 2783

WISCONSIN
MILWAUKEE 17—Neff Engineering Co., 5856 No. Pt. Washington Rd., EDgewood 2-1579

CANADA
MONTREAL—L. S. Tarshis & Sons, Ltd., 450 McGill St., Quebec, PLateau 2963
TORONTO—Trevor Babbs, National Time & Signal Co., 72 Shilton Rd., Agincourt, Ontario, OXford 1-4857

MECHANICAL AIR CONTROLS, INC.
DETROIT 37, MICHIGAN
MAC

ment and the research director are more and more concerned about increasing technological competition, rising budgets, and the demands for capital to enter new product fields."



SELF - PROTECTING wire - mesh heating element is designed to take a beating. The element, made by Electrofilm Inc., is comprised of 36 wires per inch running longitudinally and connected in parallel, while at right angles to these, another wire is interwoven 30 times per inch. Should one or more of the parallel circuit wires become damaged, the additional wire automatically distributes the current they would normally carry. Thus the heating element can be damaged in many places without impairing its performance.

It's easy to win this contest. Just enter. Every bona fide entrant gets a 620-page copy of the new *Gray Iron Castings Handbook*. To enter, choose your finest design—or redesign—of a gray iron casting. Send drawing, sketch, or preferably photographs to the Gray Iron Founders' Society, National City-East Sixth Bldg., Cleveland 14, Ohio, before June 30, 1958. Entry blanks may also be obtained by writing to this address. First-place cash award is $500, second place $100, with $50 for each of the next five winners.

ALUMINIZED KRAFT - PAPER suits protect fire fighters in large-scale tests. The expendable suit, treated to be flame-retardent, consists of a parka with hood, a face mask, a pair of leg sleeves, and a pair of mittens. Preliminary reports on the suits, designed by the Army Engineer Laboratories and fabricated by the Quartermaster Corps, indicate that men wearing the suit over duty uniforms were able to stand within 2 ft of a forest fire for two to three minutes without discomfort, although the heat was so intense that exposed portions of helmet liners were blistered.

Meetings

AND EXPOSITIONS

May 26-30—

National Packaging Exposition to be held at the Coliseum, New York. Concurrently, 27th National Packaging Conference of the American Management Association will be held May 26-28 at the Hotel Statler. Further information can be obtained from AMA headquar-

(*Please turn to Page* 44)

How a little give adds a lot of life to... AMSCO CRUSHER PARTS

Concave ring and mantle of this *Hydrocone* crusher are made of the toughest steel known... Amsco Manganese Steel. It *gives* a little, to take more punishment. *Hydrocone* is a registered trade-mark of the Allis-Chalmers Manufacturing Company.

Both mantle and concave ring crush a lot more feed because of certain properties of Amsco® Manganese Steel. The metal *gives* a little under crushing forces, absorbs stresses, resists cracking and chipping. Yet these same forces work-harden the surface of Amsco Manganese Steel to as much as 500 Brinell... a high hardness, stubborn to wear.

Amsco Manganese Steel Crusher Parts maintain their ductile undersurface and work-hardened surface even when worn thin. That's why Amsco parts endure severe abuse for so many work hours without letup.

To be sure of getting Amsco Manganese Steel, order replacement parts from your crusher manufacturer. Amsco makes manganese steel parts for most manufacturers of crushing, grinding and pulverizing equipment.

Amsco also produces other alloy steels with maximum wear resistance under particular service conditions

AMERICAN Brake Shoe COMPANY

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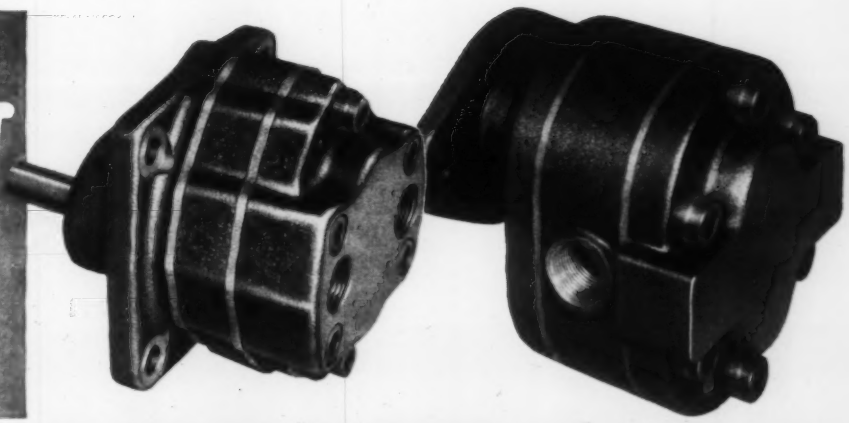
OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS, JOLIETTE, QUEBEC

NEW



TUTHILL POWERMAX

Hydraulic pumps and Fluid motors

- **For pressures to 1500 psi**
- **Pump capacities from 1.2 to 14.2 gpm**
- **For speeds to 3600 rpm**

TUTHILL, producers of quality pumps since 1927, proudly announces its new line of POWERMAX hydraulic pumps and fluid motors. Produced in a complete selection of seven different models, these rugged, compact new units incorporate the quality construction and advanced engineering that industry has learned to expect from TUTHILL.

POWERMAX pumps and fluid motors use precision-ground, involute spur gears of heat-treated alloy steel, especially designed for efficient and quiet operation. Large, heavy-duty, anti-friction bearings . . . hard, long-wearing, double wear plates of a special bronze alloy . . . double lip-type shaft seals . . . generously proportioned heat-treated alloy steel shaft . . . these are just a few of the many quality construction features which insure long, trouble-free life for POWERMAX pumps and motors.

The compact design of these units saves space and simplifies installation problems. They can be provided for either flange or foot mounting and with either side or rear ports as standard (front porting is available on special order). POWERMAX pumps or motors may be supplied with a built-in relief valve if desired.

Duplex or tandem models

For applications such as power steering where two pumps of substantially different operating characteristics are required, POWERMAX pumps may be furnished in duplex or tandem models, with both units mounted on a single shaft. This allows substantial savings through the elimination of a second driving source, reductions in hydraulic piping, and lower installation costs.

A new Catalog, No. 111, gives complete information on these new POWERMAX pumps and hydraulic motors. Included are performance curves, dimensional data, construction features . . . all the detailed engineering information you need. Write today for your copy.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

☐ Please forward copy of Catalog No. 111 on new POWERMAX hydraulic pumps and fluid motors.

☐ Please have your representative call.

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COMPANY_____

STREET_____

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Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GMP; for Pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

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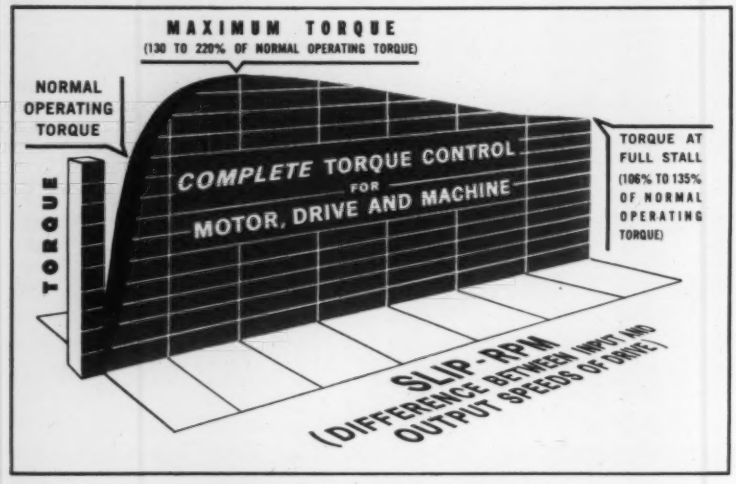
Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Circle 424 on Page 19

GRAPHIC PROOF... Whitney-TORMAG DRIVE GIVES FULL EQUIPMENT PROTECTION


MAXIMUM TORQUE
(130 TO 220% OF NORMAL OPERATING TORQUE)
NORMAL OPERATING TORQUE
TORQUE
COMPLETE TORQUE CONTROL FOR MOTOR, DRIVE AND MACHINE
TORQUE AT FULL STALL (106% TO 135% OF NORMAL OPERATING TORQUE)
SLIP-RPM (DIFFERENCE BETWEEN INPUT AND OUTPUT SPEEDS OF DRIVE)

PERFORMANCE CURVE

Now you can plot *complete* protection for your motorized plant equipment! As the curve above shows, the slip-torque characteristics of the new Whitney-Tormag Magnetic Drives bring complete protection against dangerous, equipment-wrecking *overloads* . . . complete protection from sudden, shearing *shockloads*. With the new Whitney-Tormag Drive, you get safe-capacity, *cushioned* operation from start to stop. What's more, Whitney-Tormag Drive will run for extended periods at 100% slip *full stall* — without overheating, wearing out or overloading your motor or driven parts! Add to this, Whitney-Tormag Drive's basically simple friction-free design and you'll easily understand why Whitney-Tormag Drive users report their plant *downtime* is 'way down. Magnetic Torque, you see, *never wears out!*

New 8 page Whitney-Tormag Magnetic Drive technical bulletin — be sure to get your copy!

Cost Cutting Whitney-Tormag Features

- Unique slip start design means you can use lower H.P. motors — cut your motor, starter and power costs!
- Magnetic Torque eliminates fluids, particles, seals, pumps, coolers and exciters — cuts your power drain!
- Whitney-Tormag Magnetic Drives are compact and installed in minutes. They're adaptable . . . one design for power take-off or direct drive!
- Now available in 1 and 2 H.P. (at 1750 RPM input) sizes, additional sizes up to 15 H.P. will follow. Torque ranges — 2 ft. lbs. to 45 ft. lbs.

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Be sure to visit our booth #625 at the Design Show

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

(*Continued from Page 41*)
ters, 1515 Broadway, New York 36, N. Y.

June 2-3—
Society of Naval Architects and Marine Engineers. Annual Spring Meeting to be held at the Chamberlin Hotel, Old Point Comfort, Va. Additional information is available from society headquarters, 74 Trinity Place, New York 6, N. Y.

June 2-4—
American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information can be obtained from AGMA headquarters, 1 Thomas Circle, Washington 5, D. C.

June 2-4—
National Fluid Power Association. Spring Meeting to be held at the Bedford Springs Hotel, Bedford, Pa. Further information is available from NFPA headquarters, 1618 Orrington Ave., Evanston, Ill.

June 8-13—
Society of Automotive Engineers. Summer Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

June 9-12—
National Materials Handling Exposition to be held at the Public Auditorium, Cleveland. ASME sponsored Materials Handling Conference will be held concurrently. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

June 9-13—
Fourth International Automation Exposition to be held at the Coliseum, New York. Additional information is available from Richard Rimbach Associates Inc., 845 Ridge Ave., Pittsburgh 12, Pa.

June 15-19—
American Society of Mechanical Engineers. Semiannual Meeting to be held at the Hotel Statler, Detroit.

Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

June 16-20—

American Society for Engineering Education. 66th Annual Meeting to be held at the University of California, Berkeley, Calif. Further information can be obtained from W. Leighton Collins, University of Illinois, Urbana, Ill.

June 22-27—

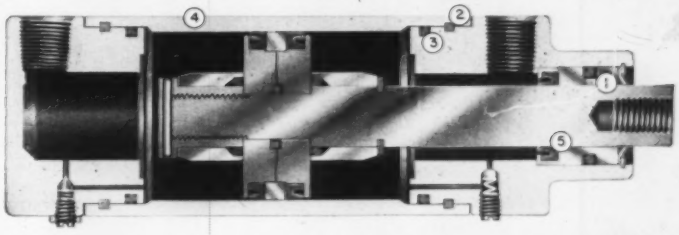
American Society for Testing Materials. 61st Annual Meeting and Exhibit to be held at the Statler and Sheraton Plaza Hotels, Boston. Additional information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 23-25—

American Society of Refrigerating Engineers — American Society of Heating and Air Conditioning Engineers joint meeting to be held in Minneapolis. It will be the 54th Annual Meeting of ASRE, whose headquarters will be at the Leamington Hotel. ASHAE will hold a semiannual meeting, with headquarters at the Nicollet Hotel. Separate technical sessions and forums will be held, as well as several joint conferences. Further information is available from ASRE headquarters, 234 Fifth Ave., New York 1, N. Y.

"Let me know when you're far enough along so we can start making a few changes."

CARTER
CYLINDERS
AIR OR HYDRAULIC



Designers get 3 Important Benefits by Standardizing on the Superior CARTER Design

THE CARTER DESIGN

1—Full 1 to 1 Meehanite cartridge rod bearing.

2—Key type stainless steel locking ring. Allows 360° rotation of ports.

3—Leakproof "O" Ring seal between head and wall.

4—Precision honed heavy wall tubing—6 to 1 safety factor.

5—Spring loaded "V" packing on rod end gland.

IMMEDIATE DELIVERY FROM STOCK

SAVINGS IN SPACE—40% savings in space. Helps build more compact, functional equipment. Where other cylinders won't fit, Carter will!

IMPROVES PRODUCT QUALITY Carter cylinders are stronger, more efficient. Completely leakproof! Better performance, longer life. The finest cylinder for your product.

ENGINEERING SERVICE and sales in 40 locations throughout the United States, Canada, Mexico, and Europe.

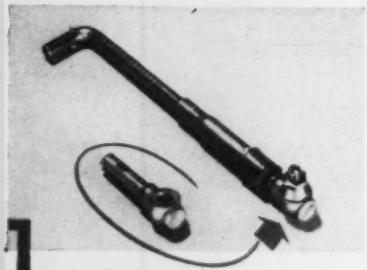
FREE DESIGNERS' FILE

Details on air, hydraulic, valves, built-in-valve types. All necessary data for designers.

CARTER CONTROLS INCORPORATED
2914 Bernice Road • Lansing, Illinois (Chicago Suburb)
Phones: Lansing—GRanite 4-3305 • Chicago—BAyport 1-7186
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

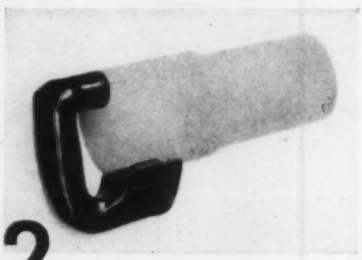
Six Standard Design Problems . . .

and how to solve them with URETHANE rubber



1. Production Cost:

Hard-wearing urethane rubber is easily cast; requires no post-finishing. *Example:* A cast urethane rubber pin and ball joint replaced machined steel in this gear shift linkage part, reducing finished-piece cost of assembly by *80 per cent!* Other advantages: Self-lubricating, vibration dampening.

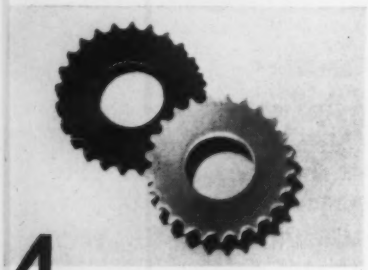


2. Vibration Dampening:

Dimensional stability and high durometer hardness make urethane rubber an ideal choice for parts subjected to shock, impact and vibration. *Example:* Handle for pneumatic hammer reduces operator fatigue and injury risk; improves guidance control. Other benefits: non-slip grip and wearability.

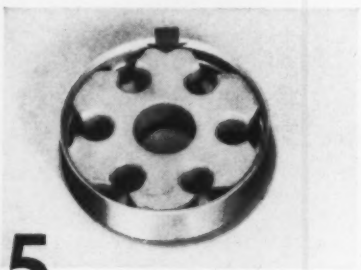
3. Maintenance Cost:

Urethane rubber is grease and oil resistant. Self-lubricating properties may be imparted, cutting maintenance costs on heavy equipment by as much as one-third. *Example:* Socket and coupling for heavy-duty ball-joint assembly. Other benefits: Lower assembly cost, no machining, vibration dampening.



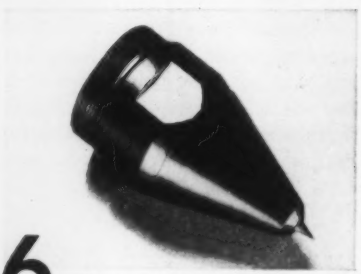
4. Noise Reduction:

Urethane rubber parts cushion while they work; completely eliminate gear noise. *Example:* Sprocket gear for a chain-driven motor bike silenced chain whine, showed no significant wear after 62,000 miles of operation. Other benefits: Lowers chain wear, maintenance costs.



5. Misalignment Stress:

Elasticity of urethane rubber permits up to 0.040 inches linear and 12° angular misalignment without malfunction of meshed parts. *Example:* This urethane rubber drive coupling replaces a laminated metal unit; has sufficient strength to transmit high horse power in rapid stop-and-go operation.



6. Abrasion Resistance:

Very high abrasion resistance enables urethane rubber to outwear ordinary rubbers by 8 to 10 times, and even steel parts in some uses. *Example:* This cast urethane rubber nozzle for sand blasting equipment replaces an all-metal nozzle; wears longer, weighs and costs less.

Other design problems requiring special properties of hardness; tensile, elongation and tear strength; rebound elasticity, high and low temperature strength, solvent and oxygen resistance, good electrical and mechanical properties, are being solved with urethane rubber. Write today for technical data, test studies and sources of fabricating assistance.

MOBAY

First in Urethane Chemistry

Mobay supplies basic chemicals and technology required for the manufacture of urethane rubber—latest addition to the growing list of urethane products for industry.

MOBAY CHEMICAL COMPANY
Dept. H-1
1815 Washington Road
Pittsburgh 34, Pa.

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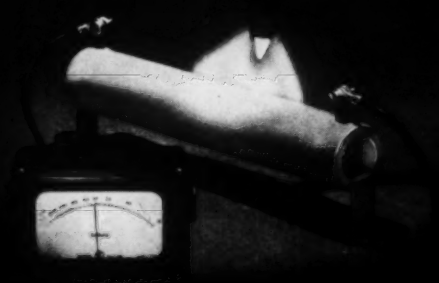
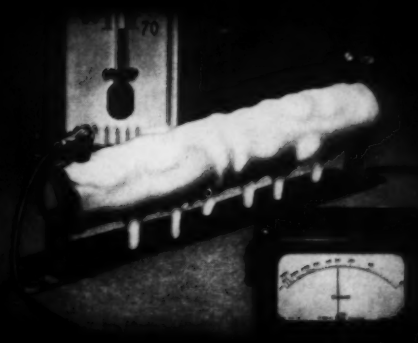


Stable operation from +700° F . . .



. . . to —70° F

Enamel resists active chemicals

Terminals withstand 21 lbs. pull

LABORATORY TESTS PROVE . . .

G-E resistors withstand heat, chemicals, stress

Actual laboratory tests on General Electric vitreous-enameled resistors have proved these important points:

Stable operation was proved by subjecting General Electric resistors to extreme ambient temperatures. Results of test: G-E resistors maintained their rated ohmic values under temperatures ranging from +700°F to −70°F.

Long operating life of G-E resistors is a result of sealing the windings with a special vitreous-enamel coating. This coating was tested with solvents, alkalies and other active chemicals. Result: no adverse effects from prolonged exposure to active chemicals.

Fewer replacements are necessary because of the sturdy construction of G-E resistors. Standard terminals hold up to 21 pounds of right-angle pull! (Special terminals withstand up to 34 pounds!)

Order G-E resistors today! Select from over 1400 combinations of ratings (5 to 200 watts), types and mountings.

NEED OTHER COMPONENTS?

General Electric also has complete lines of contactors, relays, and plate rheostats for all your control needs. For more information, contact your G-E Sales Engineer or mail this coupon today! Industry Control Department, Roanoke, Va.

GENERAL ELECTRIC

Circle 428 on Page 19

D-c contactors and relays—feature new "building-block" construction to give maximum flexibility with minimum inventory.

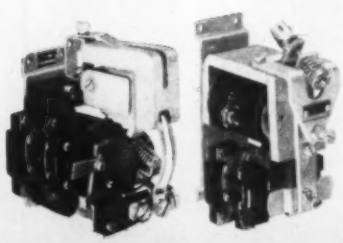


Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.

To: Section B784-11
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- ☐ GEA-6592—Vitreous-enameled resistors
- ☐ GEA-6474—Plate-type field rheostats
- ☐ GEA-6621—D-c contactors and relays

Name_____

Company_____

Address_____

City_____ State_____

ELECTRONIC and ULTRASONIC quality control of MUELLER rod, tube, fabricated parts and

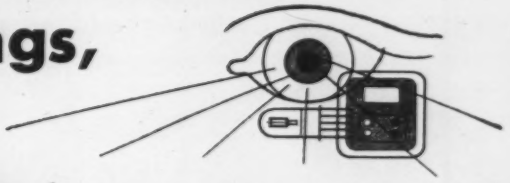
Every practical electro-mechanical testing device available to industry today is used by the Mueller Brass Co. to maintain Positive Quality Control during each manufacturing operation. From the first stages of alloying, spectroscopic analysis is used to maintain exact alloy composition so that they are precisely as specified. Ultrasonic test equipment is utilized in the non-destructive testing of extruded brass and bronze rod, copper tube, forgings and fabricated parts. In machining and finishing operations, statistical quality control is employed to eliminate the effect of possible human error. These quality controls are all designed for one purpose . . . to give you complete "product protection."

•

Copper base alloy rod is examined by a trained operator with the aid of an ultrasonic reflectoscope. Through electronic circuitry, ultrasonic echoes are translated on a cathode ray tube. Any internal flaws are readily apparent. Both rod and tube are tested by this method, which is just one of many Positive Quality Control checks used by the Mueller Brass Co.

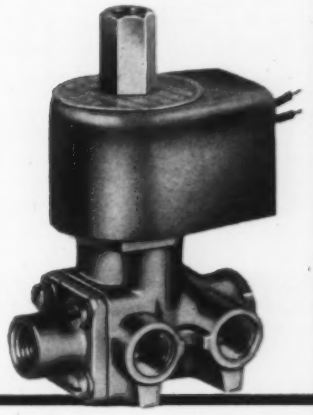
Through ultrasonics, the immerscope (Left) locates internal defects, and has exceptional versatility for examining intricately shaped parts, such as the forging being checked in this photo. When testing, a transducer, located at the bottom end of the search tube, is electronically actuated to produce from 2.2 to 25 million cycles per second. Ultrasonic echoes are reflected back to the transducer from the material, indicating any defects that may be present. Limits may be pre-established and the sound findings are visually recorded on the cathode tube. This is another instance of Positive Quality Control in action.

TESTING helps insure positive BRASS CO. forgings, assemblies...



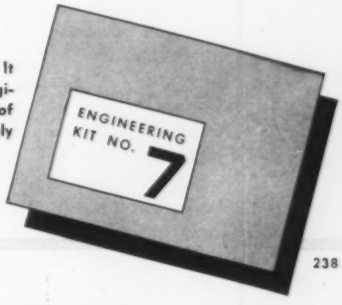
The direct reading spectrometer (Left) makes it possible to accurately analyze an alloy for chemical composition within 90 seconds while the metal is in the molten stage. A sample specimen is poured, cooled and sent to the laboratory, where it is placed in the spectrometer. Through the diffraction gratings in the machine, the "spectrum" analysis of the alloy records its exact chemical composition. With this equipment, alloy specifications are matched exactly, thus insuring a better finished product through Positive Quality Control.

THIS MIDGET 4-WAY SOLENOID VALVE (Right) is one of a complete line designed and manufactured by the Automatic Switch Co. of Florham Park, New Jersey, and is used for operating valves, dampers, and many types of automatically controlled equipment. One of the most important components in these valves is the non-porous brass body forged by the Mueller Brass Co. who also perform all the major machining operations so that the body is ready for use upon delivery. The forged brass body insures freedom from porosity and reduces possibility of corrosion. The Mueller Brass Co. Positive Quality Control program insures ASCO complete "product protection" . . . and eliminates chance of "in-service" failures.



THIS LARGE 18" FORGED GEAR, along with two others of the same type, is used in a steam turbine installed in a power generation facility of the Wisconsin Electric Power Company, at Port Washington, Wisconsin. The gear was forged in open dies by the Mueller Brass Co. from tough, long-wearing 603 alloy. The gear operates at 25-30 RPM and is turned by the turbine, which has a capacity of 80,000 kilowatts. Strength and dependability are of utmost importance in applications like this, and in such cases Positive Quality Control insures peak performance.

Write for your engineering kit no. 7. It contains complete laboratory and engineering data plus typical examples of Mueller Brass Co. products used in widely diversified applications.



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MUELLER BRASS CO. PORT HURON 20, MICHIGAN

Impact resistance—The image of impact can take many forms. To a train-conscious youngster, impact might be the crash-coupling of freight cars. To the contour miner, impact is a mammoth dipper smashing into frozen highwall. To the ordnance man, impact is a shell striking armor plate. Whatever the image, impact implies one thing—toughness.

Toughness is the ability to absorb energy—to "give" under a shock load without fracturing. This property—toughness—in steel, more than in any other material, has been vital to the building of the modern world. Steel's ubiquitous role, however, belies the complexity of toughness. Because just as there are many kinds of steel, so there are many degrees of toughness, and a given steel's toughness is shaped by the admixture of its composition, manufacture and fabrication.

The design engineer, if he is to do his job well, must know his toughness in order to select the right steel for the job. He must know something of how toughness is achieved, because this often can result in using less expensive steels. The geometry of a part or structure is also important to its toughness, and here the designer reigns supreme.

In steelmaking, toughness and strength are determined by composition and manufacturing steps. Often, as is the case with USS* "T-1" Constructional Alloy Steel, a very high level of strength and toughness is obtained through selection of alloying elements and by proper heat treatment. The steelmaker can help you obtain the best combination of strength and toughness along with other desirable properties like weldability, corrosion resistance, formability and wear resistance. He can also recommend post-fabrication heat-treating practice where it is required to develop mechanical properties or relieve stress in fabricated assemblies.

Clearly, toughness is complex. But for any application, there is one best steel no matter what combination of properties you need. You are almost certain to find that steel among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless. Our experience is yours for the asking. Write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. You'll find our nearest representative in the Yellow Pages listed under United States Steel.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS *TRADEMARK **United States Steel**

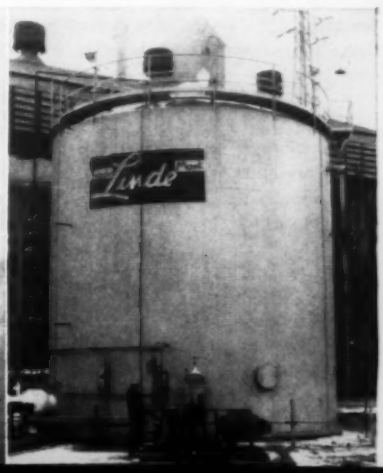
Circle 430 on Page 19

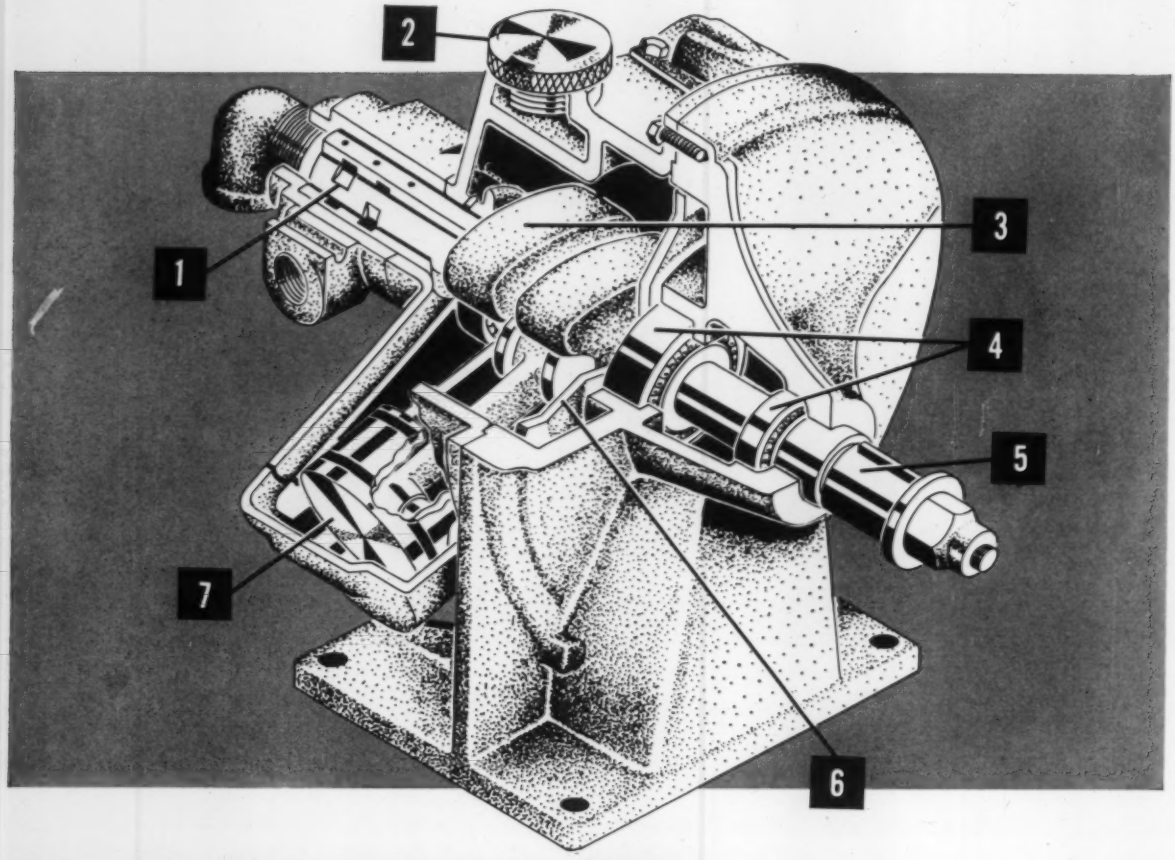
STEELS FOR DESIGN

Lower Left—Problem: Design dump cars for tunnel excavations to remove rock. Must have high impact resistance, plus corrosion resistance to withstand alternate wetting and drying. Solution: Build cars from USS COR-TEN* High Strength Steel. Pay-off: Cars take minimum maintenance, have been in continual service for six years, and are still in excellent condition.

Lower Middle—Problem: Design a 60 cu. yd. shovel that could take the terrific abuse of all-weather overburden removal. Solution: Bucket, bail, dipper stick and crowd rack built entirely of welded USS "T-1"* Steel, a constructional alloy steel having exceptional toughness at below zero temperature and which can be field-welded and flame-cut. Pay-off: Outstanding performance in 7-day-a-week, 24-hour-a-day service with minimum maintenance.

Lower Right— Problem: Design a tank to hold the liquid equivalent of 10 million cubic feet of oxygen at 300°F. below zero. Solution: Tank was designed with impact-resistant austenitic USS Stainless Steel. Pay-off: Tank can withstand sudden changes of pressure, temperature changes and volume at low temperatures that would shatter other materials.





Smooth, high torque to 16 hp. ... Gardner-Denver 5-cylinder radial air motor

Check construction

1 Distributor valve for efficient compressed-air use.
2 Simple lubrication. Filler plug for crankcase oil—oils motor and bearings.
3 Counterbalanced crankshaft.
4 Heavy-duty, oil-lubricated roller bearings.
5 Rigid shaft supports overhung loads.
6 Oil slinger ring.
7 Automotive-type pistons and rings seal in power . . . save oil.

Check operation

- Smooth, even torque at all speeds . . . vibrationless operation.
- Accurate counterbalancing and overlapping power impulses.
- Extremely high hp in relation to air consumption.
- Not dependent on high rpm for power.
- Operates and consumes air only when working.
- At least two cylinders always on power stroke—three during part of cycle.

Check features

- High torque and control flexibility.
- Freedom from overload damage.
- Can't spark . . . can't burn out.
- Quick starts and stops . . . continuous operation.
- Six models available, with power and speed for variety of applications.
- Sizes from 2 to 16 hp.
- Direct drive or built-in gear reduction, reversible and non-reversible models.

For complete information, request Bulletin AM-1.

GARDNER-DENVER Since 1859 KELLER TOOLS

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois
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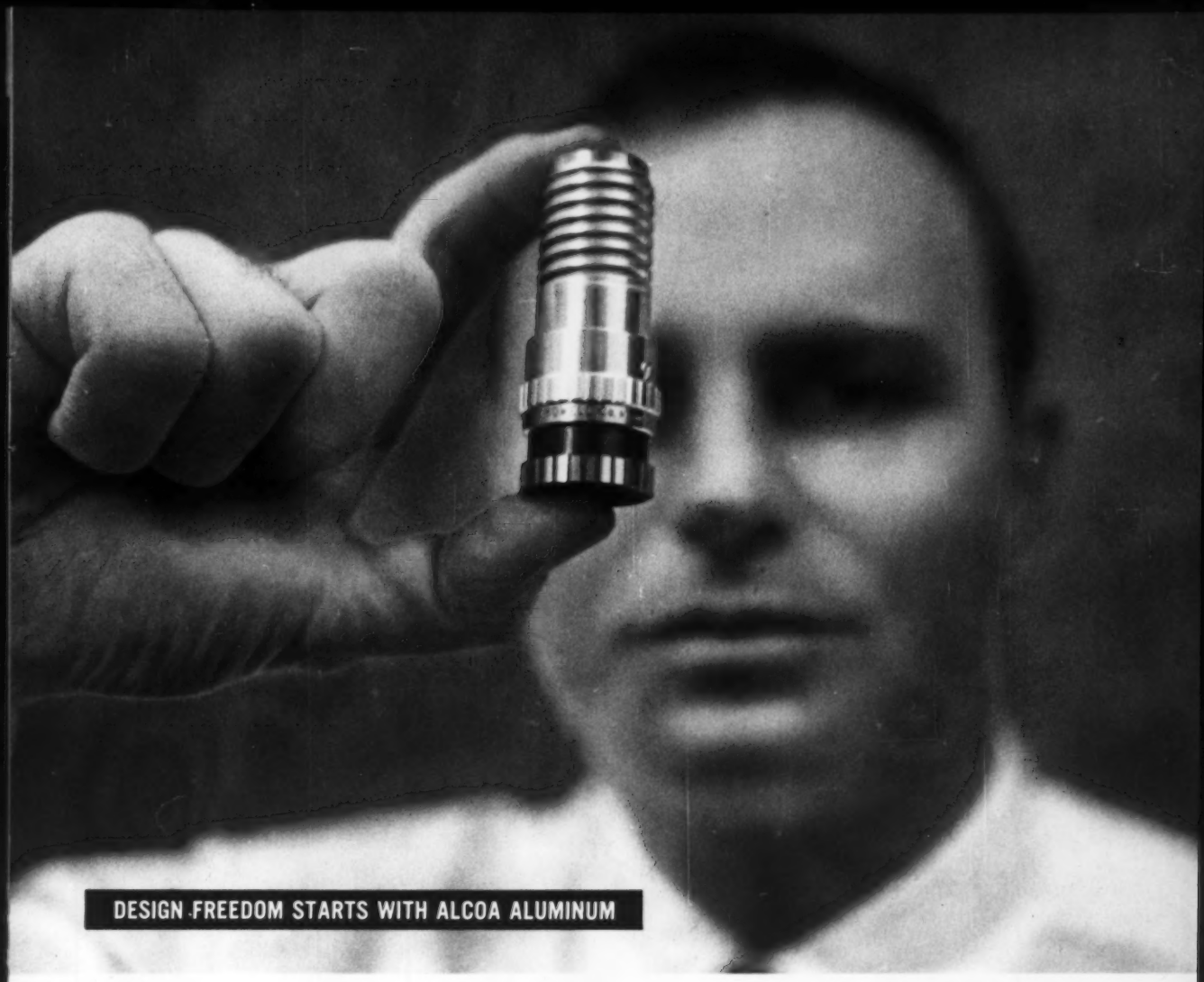


BELL & HOWELL GOT COLOR • TAYLOR INSTRUMENT SAVED $100,000 ANNUALLY • DICTAPHONE REDUCED PRODUCT WEIGHT

WHAT DO YOU WANT IN SCREW MACHINE STOCK?

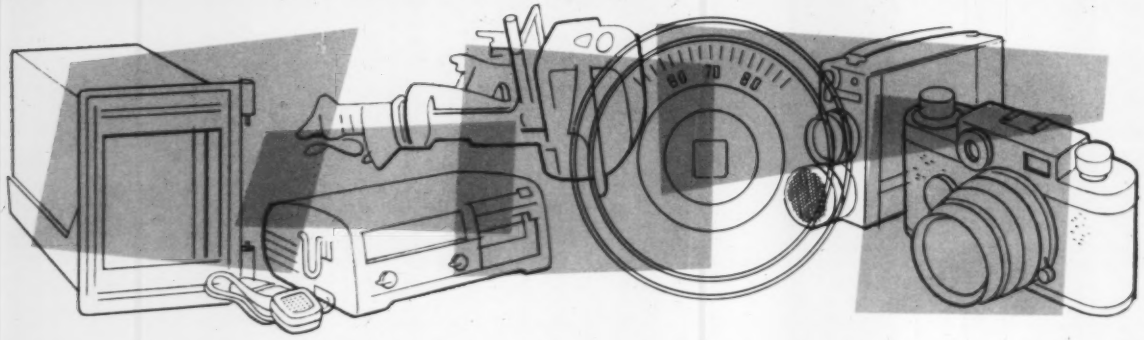
You can get parts in any color with aluminum

The designer today who wants lasting color specifies color anodizing with Alcoa® Aluminum—lustrous color that stays new and fresh because it's part of the metal—color that does not distort dimensions.

Color means eye-appeal for more sales. Would color attract more customers to your product? Bell & Howell asked this question, then switched to gold-anodized aluminum for its new Filmovara zoom projection lens. Now Alcoa Screw Machine Stock adds new beauty to a famous camera and projector line.

Color means eye-appeal for more safety. Does your product have controls where a wrong move means time, expense, accident? Square D's push-button controls electrically operate everything from single machines to assembly lines. They switched to Alcoa Aluminum Screw Machine Stock for colored buttons that are oiltight and metal rugged.

GET DESIGN FREEDOM WITH ALCOA ALUMINUM SCREW MACHINE STOCK



Result: operators now see at a glance what's what, make fewer mistakes.

Color means eye-appeal for better identification. Screw machine parts of Alcoa anodized aluminum are easier to see, stock, inventory and assemble. And color anodizing adds extra protection to aluminum's inherent resistance to corrosion.

You can cut costs with aluminum

You buy screw machine stock by the pound—you machine it by the foot. Alcoa Aluminum gives three times more parts per pound than steel or brass. Aluminum machines faster—cutting speeds as high as 1,000 feet a minute are common. Result: aluminum parts can cost less than steel or brass. It works out this way . . .

. . . aluminum vs steel: machine time makes the difference.

. . . aluminum vs brass: more parts per pound makes the difference.

Here's another way to look at it:

1. Aluminum costs less than brass, machines just as fast.
2. Aluminum machines faster than steel and won't rust.
3. Aluminum scrap allowance is higher than either.

Taylor Instrument Company proved it. By converting 40% of its parts to Alcoa Aluminum Screw Machine Stock, Taylor saved $100,000 annually. And Taylor reports performance equal to or better than other metals.

You can reduce product weight with aluminum

Designers who want less weight specify Alcoa Aluminum. Aluminum weighs less than steel or brass, so the end product weighs less. A switch to Alcoa Aluminum Screw Machine Stock played a major role in reducing the weight of Dictaphone Corporation's Time-Master dictating machine from 20 lbs to 12.4 lbs.

Aluminum weighs less than steel or brass, so it's easier on automatic screw machines and uses less power. Enterprise Manufacturing Company, maker of Pflueger fishing tackle, reports that aluminum gives longer tool life and closer tolerances on drilling, milling, tapping and machining.

Aluminum weighs less than steel or brass, so it's easier to move, stock and handle. Minneapolis-Honeywell reports that its men like aluminum's lightness, especially in the 2⅛" size they use.

Aluminum offers superb machinability

A free-machining metal, aluminum machines as well as free-cutting brass. Aluminum is machined as fast as the machine will run. Dictaphone Corporation reports, "We chase an acme thread in aluminum with two passes, compared to six or seven in stainless."

Aluminum takes any finish

You can polish, buff, brush or burnish aluminum screw machine parts. And the initial fine appearance does not deteriorate—designers no longer need to worry about rusting. Bell & Howell reports that aluminum ensures lasting, maintenance-free color.

Aluminum scrap is worth more

Aluminum scrap brings more per pound than either steel or brass. Argus Cameras, Inc., reports that many of its parts require 75% stock removal. "Aluminum's high machinability and high scrap value help us greatly."

WHAT DOES ALL THIS MEAN TO THE DESIGNER?

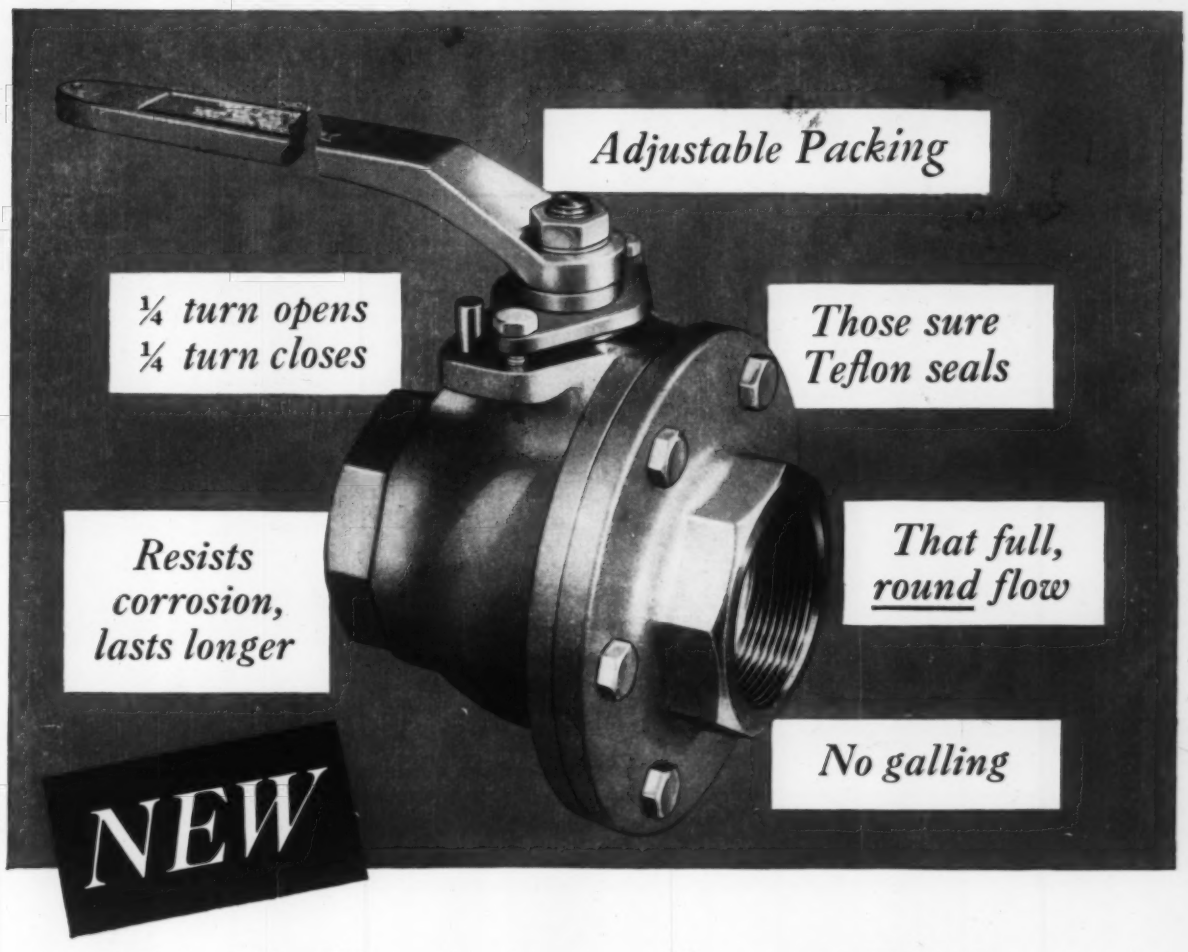
Aluminum provides optimum design freedom. Aluminum gives exceptional machinability—limited almost entirely by machine capacity; high electrical and thermal conductivity; choice of any finish—or color; always less weight and frequently lower in cost than steel or brass. Summation: fewer restrictions on the designer.

For more about conversion to Alcoa Aluminum Screw Machine Stock, call your nearest Alcoa sales office. For prompt delivery of Alcoa Aluminum Screw Machine Stock, contact your local Alcoa distributor. Send for Alcoa's new booklets about aluminum screw machine stock. They contain direct quotes from design engineers, production engineers and purchasing agents of leading industries on why they switched to Alcoa Aluminum. ALUMINUM COMPANY OF AMERICA, 873-E Alcoa Building, Pittsburgh 19, Pa.

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

Look for this label. It's your guide to the best in aluminum value.

ALCOA ALUMINUM



"316" Stainless Steel Valve

also brings you all the proven Rockwood features, too

You get more. But you give up nothing. That's the story of the New Rockwood Ball Valve in Type "316" Stainless Steel with Teflon Seals and Trim.

And it's "yes" to all the other features that have given Rockwood Ball Valves their good name. You don't get galling . . . you do get full round flow. Low pressure sealing, easy operation, stem repacking without removal from the line — all these are yours with Rockwood.

The New Rockwood Ball Valve comes with various types of seats, remote air-operation of wanted sizes and with adjustable stem with Teflon packing, screwed (⅜" to 2") ends. Send for specifications. Distributors in all principal industrial areas. Rockwood Sprinkler Company, Worcester 5, Massachusetts.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER CO.
2172 Harlow Street
Worcester 5, Massachusetts

Please send me folder which includes specifications on the NEW ROCKWOOD "316" STAINLESS STEEL BALL VALVE.

Name.....

Title.....

Company.....

Street.....

City.....Zone....State.....

Circle 431 on Page 19

PRECISION WASHERS

For automatic transmissions and similar bearing applications

FEDERAL Mogul

Solid steel or bronze; steel faced with babbitt or copper-lead, or copper-lead on *both faces*. Flat, spherical or special shapes. Grooves, holes, nibs, scallops or lugs. O.D. 1″ to 6″. Wall thickness: solid, .028″ to .141″; bimetal, .034″ to .141″. Cold rolled for heavy-duty. Large capacity. Complete engineering service.

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 432 on Page 19

HELIARC Welding
breaks the light-gage metal barrier

Welding stainless steel sheet into a smooth, streamlined shape for jet plane fuel tanks is a production job for HELIARC Welding. This method, utilizing a tungsten electrode shielded by LINDE Argon, was developed by LINDE especially for use on hard-to-weld commercial metals.

HELIARC Welding can be used either automatically or manually, in all manual welding positions. LINDE Argon in bulk or in cylinders—99.995% pure—protects the weld. Since no flux is required, joints are clean and smooth, without spatter, saving you time and money.

Get more information about HELIARC Welding. For a free copy of the booklet, "Modern Methods of Joining Metals," write Dept. Q-52. LINDE COMPANY, Division of Union Carbide Corporation. 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

Fuel tanks for jet planes, made of thin stainless steel, are quickly assembled with smooth, clean and sound seams by HELIARC Welding, a LINDE development.

FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!

Linde TRADE-MARK
UNION CARBIDE

The terms "Linde," "Heliarc," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

NEW precision FLOW CONTROL at production prices

MULTI-RANGE FLOW CONTROL

- extra-sensitive flow control adjustment...for precise flow settings
- temperature-viscosity compensated...no change in selected flow rate
- available for the first time in all 3 sizes...1/4"—3/8"—3/4"

EXCLUSIVE WITH DENISON

Here's how to solve the problems of uniform feed rate . . . optimum precision work finish and cutter life so vital in modern machine tool equipment.

With the new Denison Multi-Range Flow Control in your design system, you can count on these important advantages and features . . . all pioneered through Denison advanced engineering:

- **PRECISE FLOW SELECTION** . . . is made possible through a new extra-sensitive control with an exceptionally wide span of adjustment in any given range.
- **MULTI-RANGE CONTROL** . . . allows one model to do the work of many—also simplifies your inventory. Adjustment from one range to another is guarded by stops to afford safe, simple, foolproof operation.
- **UNIFORM RATE OF FLOW** is assured because Multi-Range Flow Control is virtually free from flow change due to temperature-viscosity changes.
- **SURGE OVERTRAVEL VIRTUALLY ELIMINATED** —by simple adjustment—to avoid erratic feed of slides as the valve finds its setting.
- **BUILT-IN RELIEF VALVE** saves space and cost of additional piping.
- **BUILT-IN CHECK VALVE** permits reverse free flow.
- **REQUIRES NO EXTERNAL DRAIN.**
- **PRODUCTION PRICED** . . . and built to JIC Standards for operating pressures to 2000 psi.

MACHINERY DESIGNERS—ENGINEERS!
Write for Bulletin VFC-3.

INFINITELY VARIABLE CONTROL—The maximum capacity in a given range can be *varied infinitely* to permit setting the full scale of the valve itself to the exact maximum that the system requires.

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Denison, Denison HydrOILics and Multi-Range are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Circle 434 on Page 19

ILLINOIS SETS THE PACE IN BIG

★ Here is progress-in-action to meet the fast-moving, ever-changing requirements for large gears in industry.

ILLINOIS GEAR has been meeting this challenge by constantly adding new, modern production facilities . . . the latest of which is the equipment illustrated here. It is the *newest, largest and most modern of its kind in the world.*

Spectacularly large, this precision gear cutting, hardening and testing equipment will handle spiral, Zerol and hypoid bevel gears up to 94" pitch diameter, 13" maximum face, .625 D.P. (5½" C.P.) 2.875" tooth depth and hypoid pinions to 10" offset.

These large precision gears offer new possibilities that may well open new horizons in the design of your equipment. Ask for full information today.

SPIRAL BEVEL GEARS

ZEROL BEVEL GEARS

HYPOID BEVEL GEARS

up to 94" diameter and 13" face

Look for this mark ILLG® *the symbol on finer gears*

ILLINOIS GEARS Reg. U.S. Pat. Off.

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

Circle 435 on Page 19

"BANK ON"

US® SHAFTS...

VITAL PART OF YOUR PROFIT DOLLAR

A broken shaft on a single piece of equipment can "pull the pin" out of your profit machinery fast! With U.S. shafts, you, too, can bank on extraordinary dependability and long life. Why? Our 38 years of top quality manufacturing by specialists in shaft engineering and production. Fine alloy steel, modern heat treating, and shot-peening for extra strength provide up to *5 times greater toughness*. No wonder that so many of industry's wheels turn more profitably on U.S. Shafts!

Custom designed to do your job better, faster, more dependably, more profitably! Write today for our valuable FREE Brochure.

FREE

VALUABLE BROCHURE

Shows you why U.S. Axle is your best source for precision-made special shafts.

THE U. S. AXLE COMPANY, INC.
Pottstown, Penna.

Please send me the brochure on "U.S. Custom-Engineered Shafts."

Name_____

Firm_____

Address_____

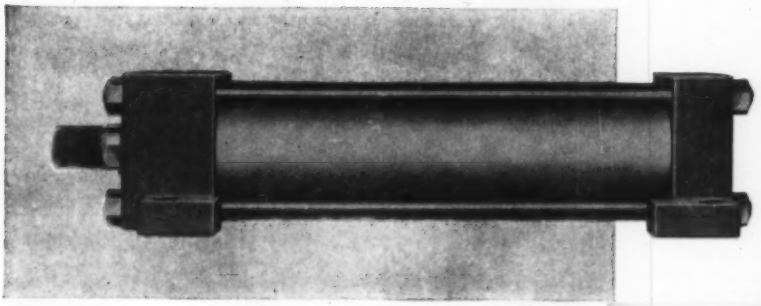
City_____ Zone____ State_____

"THE WORLD TURNS ON U. S. AXLES"

THE US AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania

Circle 436 on Page 19

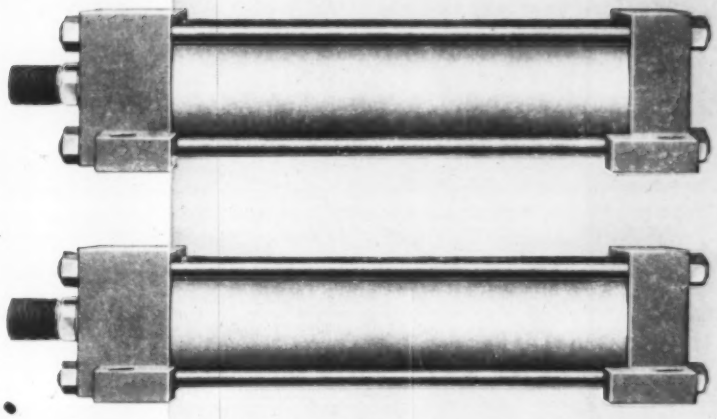


◀ A LOGAN SUPER-MATIC CYLINDER

2 competitors' cylinders

▼

do they LOOK ALIKE? ...sure they do on the surface...



...BUT LOOK AT Logan's BIG EXTRA PLUS VALUES

Logan Super-Matic Cylinders

are made to interchange with other leading manufacturers' cylinders . . .

1. Logan designs assure the service required for those extra-rugged applications.
2. Over FORTY YEARS of cylinder manufacturing know-how.
3. Built by CRAFTSMEN whose average service record with LOGAN is more than 20 years.
4. Manufactured in a plant which applies the most modern production methods.

FREE

SEND FOR THE "LOGAN CALCULATOR"

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-6 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 AND 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

Circle 437 on Page 19

Tubexperience in action

Your carbon hydraulic tubing with Superior

gets 100% permanent protection rust preventive!

*Superior (SAE) Carbon Hydraulic gives you the smoothest, most brilliant ID and OD finish you can buy. Made from non-aging steel. Carbon content is only .12% maximum for high ductility. Every length is 100% hydrostatically tested. You get maximum performance and minimum turbulence, plus long service life.

You get all this, *plus one important extra that makes Superior hydraulic tubing your best investment—a rust preventive that gives 100% positive protection indefinitely!*

Just dip it and use it! Superior rust preventive comes off easily, leaves tubing clean and bright, just like new.

GET EXTRA SAFETY WITH SUPERIOR

There is a reason for use of the special rust preventive on Superior hydraulic. Thin oil coatings are not sufficient protection. They will bleed or rub off—and when the tubing is to be used, it shows patches of rust and pin spots where pitting has begun. The tubing no longer meets specifications, because that marred ID is sure to cause pressure trouble and excessive turbulence. But the high protection you get when you buy Superior hydraulic assures you of tubing that is always ready for service, weeks or months after you buy it.

Each length of Superior hydraulic tubing gets an all-important coating of rust preventive. This microcrystalline wax material sheathes the tube in an unbroken film inside and outside. It sets quickly, will not run or rub off during shipment, is not slippery or messy to handle, will not bleed over your storage racks. Tubing is safeguarded against rusting, corroding, staining or tarnishing in damp or corrosive atmospheres.

EASILY REMOVED

The rust preventive can be removed as simply and quickly as lighter, less efficient coatings. Simple immersion for a 5-minute maximum in any of a variety of standard cleaners (Stoddard, kerosene, cleaning solvents such as trichloroethylene, or commercial alkali cleaners) is sufficient.

A REMINDER

Remember—normally you buy your tubing from a distributor (a steel service center). To give you the best possible service, he must stock carbon hydraulic in his racks. It may be there a month or two—even longer. But if you specify Superior (SAE) Carbon Hydraulic, you know it will reach you as bright and shiny as the day it was drawn. Just dip it and use it!

Superior hydraulic tubing is available through leading steel service centers from coast to coast. For the name of your local Superior Tube distributor and a free copy of Bulletin 39, write to Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

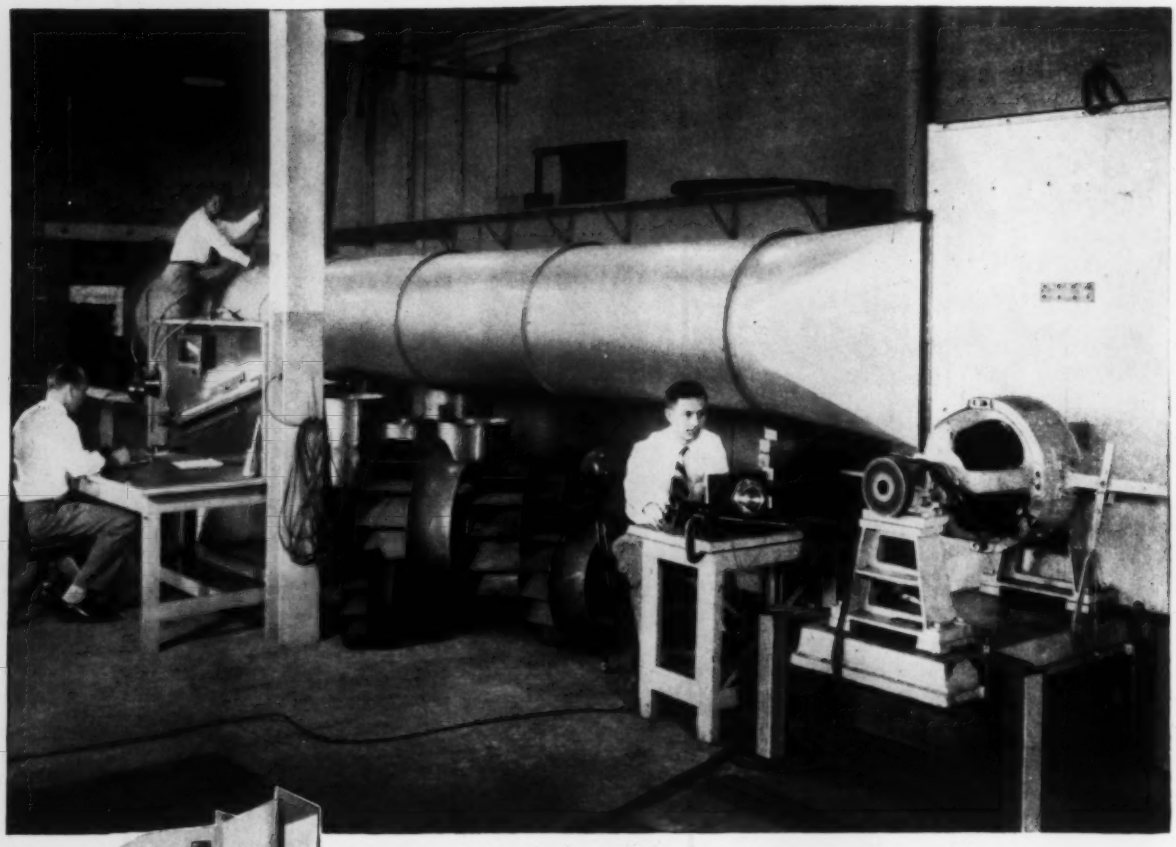
Superior Tube

THE BIG NAME IN SMALL TUBING

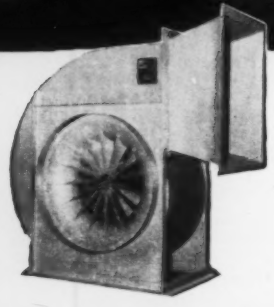
NORRISTOWN, PA.

All analyses .010 in. to 3/8 in. OD—certain analyses in light walls up to 2 1/2 in. OD.

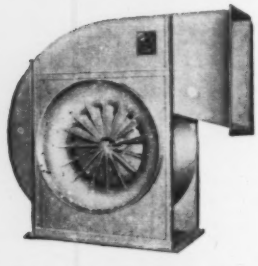
West Coast: Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331



Complete Test Setup at "Buffalo" to Check Fan Wheel Performance Over Entire Range of Operation.



92% Mechanical Efficiency — attained by the "Buffalo" Airfoil Fan.



"Buffalo" Type BLH Fan for Classes II - IV air handling.

WE PAY THEM NOT TO BE SATISFIED —SO THAT YOU WILL BE!

Fan designing and testing at "Buffalo" are jobs that are never "completed" — because once an improved model tests out, our engineers go back to work on a better one!

That's the spirit of dissatisfaction which developed the series of "Buffalo" Airfoil and Semi-Airfoil Fans with choice of wheels to match widely varying requirements — the Types BL and BLH Fans to cover all pressure classifications. And though these fans have set new records for efficiency and stable performance, the work still goes on toward even higher goals. Meanwhile, you get the benefits: the best of hundreds of tested fan designs — the most complete selection of fans for the exact performance you require — the *"Q" Factor or built-in Quality which provides trouble-free satisfaction and long life.*

Write for Bulletins F-200 and FD-106. See why "Buffalo" means a better fan buy.

BUFFALO FORGE COMPANY
BUFFALO, N. Y.

"Buffalo"

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 439 on Page 19

variable speeds direct from standard AC power lines...with

U.S. VARIDRIVE MOTORS

Smooth, stepless speed changes to the split RPM—with the simple, completely self-contained U.S. VARIDRIVE MOTOR! Just plug into any standard AC power line.

Why bother with DC Converter, DC Generators, complicated electronic tubes and circuits that require special technicians? Why risk costly production shutdowns?

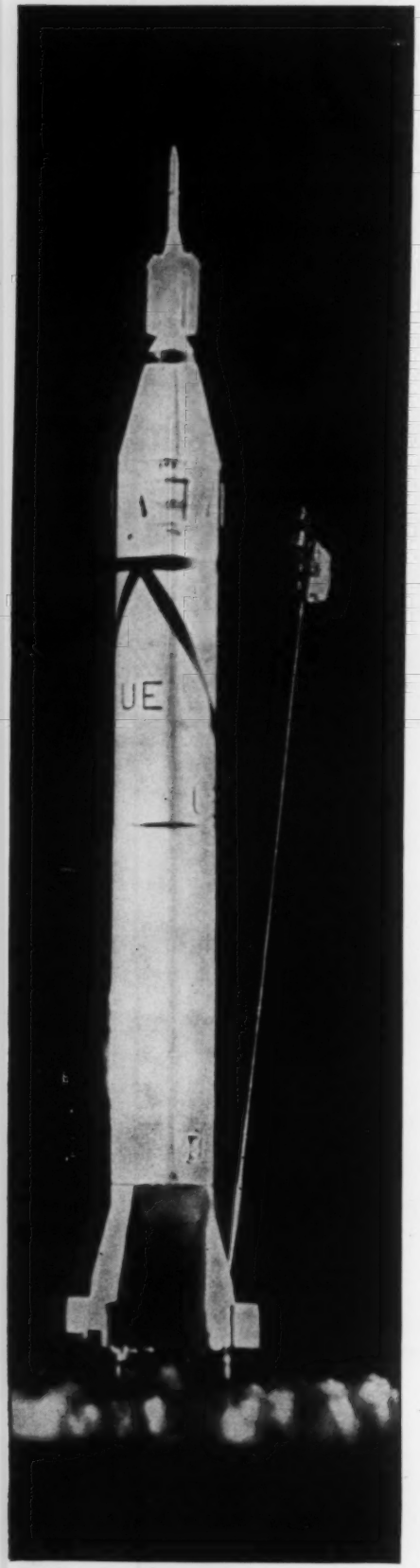
You avoid complications when you choose U.S. VARIDRIVE—dependable, simple, easy for ordinary personnel to maintain. Available in RATINGS ¼ TO 60 H.P. Specify: "U.S. VARIDRIVE MOTOR."

U.S. ELECTRICAL MOTORS INC.

P. O. BOX 2058, LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

FREE COLOR-ILLUSTRATED BROCHURE
... Send for U.S. Varidrive Bulletin 1797

Circle 440 on Page 19



Republic Stainless Steel Circles the World

When "Explorer I" was successfully placed in orbit by the U.S. Army from Cape Canaveral on January 31, a new era was opened for the use of Republic ENDURO® Stainless Steel.

Vital instruments in the nose section of the satellite are protected by a cone of stainless steel produced by Republic. This nose cone was fabricated from Type 430 by The Lodge and Shipley Company, Cincinnati, Ohio, using the Floturn Process. By flow-turning, the wall thickness of the cone can be increased in specific areas to comply with design requirements of high temperatures or stresses.

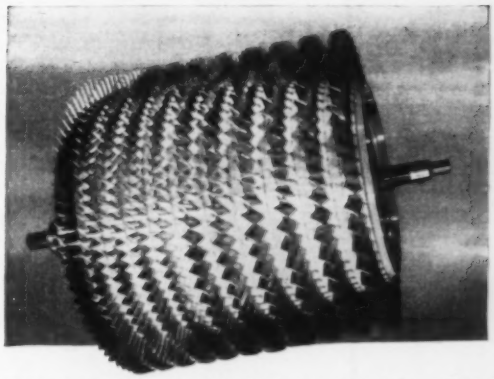
Stainless Steel is highly ductile. It is readily formed into desired shapes by cold-forming, drawing, and bending operations. It provides low thermal expansion and is highly resistant to atmospheric corrosion, erosion, and oxidation at high temperatures.

Republic is the world's largest producer of stainless, heat-resisting, and alloy steels. As rapid developments in the fields of supersonic aircraft and missiles increase demand for these high-strength, select formula steels, Republic is keeping pace through research and new production facilities.

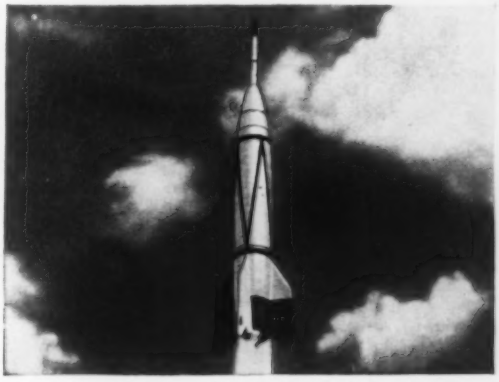
Our metallurgists and engineers are always available, without obligation, to work with your personnel in using Republic Stainless Steels, Heat-Resisting Steels, Alloy Steels, and Titanium to best advantage. Check and mail the coupon if you would like a Republic specialist to call at your plant.

Official U.S. Army photograph shows launching of Jupiter-C Missile and "Explorer I" Satellite from Cape Canaveral, Florida, 10:48 PM, EST, January 31, 1958.

"Explorer I" is positioned on spin launcher. The satellite is spin-stabilized in much the same manner as a rifle bullet. Rotational spin of more than 700 RPM was started on the ground before the satellite was launched. In this Official U. S. Army photograph, the striped area at the top of the Explorer indicates the nose cone fabricated from Republic ENDURO Stainless Steel, Type 430.



REPUBLIC ALLOY STEEL provides high strength and dependable toughness in jet engine compressor rotor discs. In Pratt & Whitney's J-57 jet engine, Republic Hot Rolled Alloy Steel, AMS 6415 (AISI 4340), furnishes the highest strength values—plus an exceptionally high strength-to-weight ratio that permits the design of thinner, lighter sections to save weight and hold down size without sacrifice of strength or safety. The discs are machined from forgings by the Jet Division of Thompson Products, Inc. Forgings are supplied by Wyman-Gordon Company.



REPUBLIC TITANIUM is currently being used for many applications in both aircraft and missiles. Because of its high strength and weight saving factors, titanium has replaced other materials normally used for firewall and nacelle construction. In missiles and rockets it has almost unlimited applications. Titanium's extremely high corrosion-resistance makes it attractive for tanks to hold acids used in combination with missile fuels. Nitric acid, for example, has negligible effect on titanium. It is practically immune to salt water and sea air corrosion. Send coupon for more facts.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-5576
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Have a metallurgist call.
☐ Stainless Steel ☐ Alloy Steel ☐ Titanium
Send more information on:
☐ Stainless Steel ☐ Alloy Steel ☐ Titanium

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 441 on Page 19

Engineering problem:

Pressure-tight fastening of transit cases

The solution:

A specially modified LINK-LOCK

Applied Design Company engineers worked with Simmons to develop this successful LINK-LOCK application

Simmons LINK-LOCK, with design modifications developed in cooperation with the Engineering Department of Applied Design Company, Buffalo, New York, resolves special closure requirements in rigidly specified transit cases like the aluminum equipment container shown.

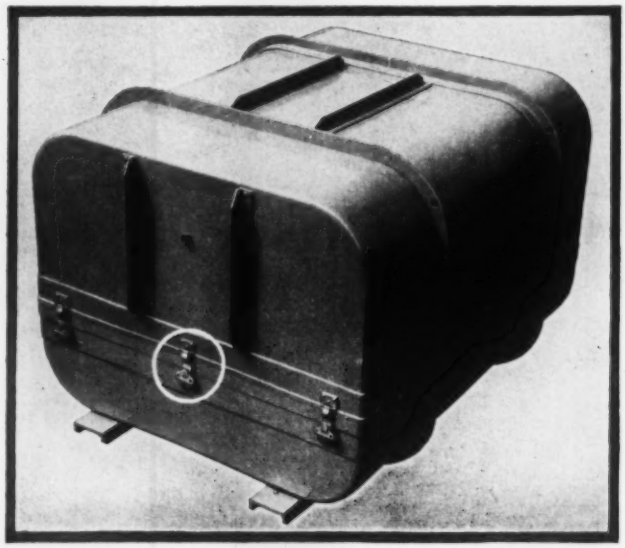
Here, the bowed LINK-LOCK engagement blade provides the double advantage of maintaining constant fastener pressure and permitting considerable mounting tolerance. This container is just one of many important products in which Applied Design specifies standard and special Simmons Fasteners.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

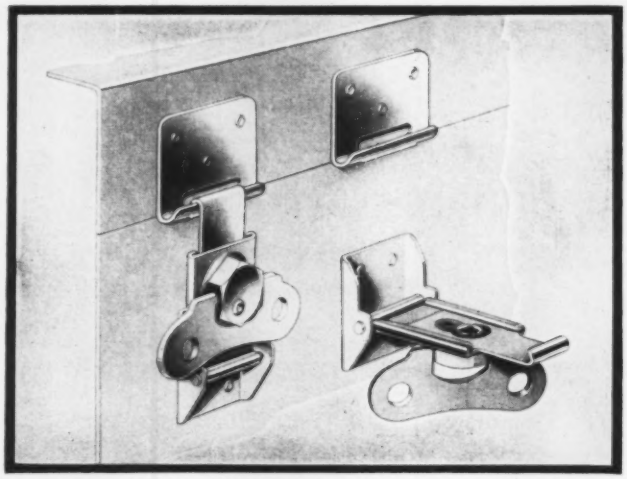
- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design... lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design... can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

SEND TODAY for the Simmons Catalog for complete information and engineering data on LINK-LOCK and other Simmons Industrial Fasteners. Engineering service is available; outline your particular fastening problems. Samples on request.



Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

SIMMONS

FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

See our 8 page catalog in Sweet's 1958 Product Design File

Circle 442 on Page 19

the man from Webster...

on your team but on our PAYROLL!

Sound ideal, doesn't it? In practice, it's even better. When you call the man from Webster, you add another expert to your team — a specially trained hydraulics engineer. He knows how to make hydraulics work most efficiently on your product. Another advantage too, is his wide experience with the Webster line of over 100 positive displacement, gear-type pumps and fluid motors . . . standard equipment on products with a reputation for dependability, high performance.

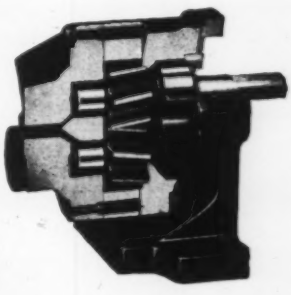
Write or call the man from Webster — a good man to have on your team.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 3-3511
RACINE · WIS

OVER 100 MODELS

Capacities: *1/5 to 30 GPM*
Pressures: *Up to 1500 PSI*
Speeds: *Up to 3600 RPM*
Drives: *Direct or Geared*
Torques: *Up to 60 in. lbs./100 PSI*
Available with or without built-in relief valves



H-107

☐ *Have THE MAN FROM WEBSTER contact us—*

- Please send the following -

☐ *Complete hydraulic catalog of pumps and valves*

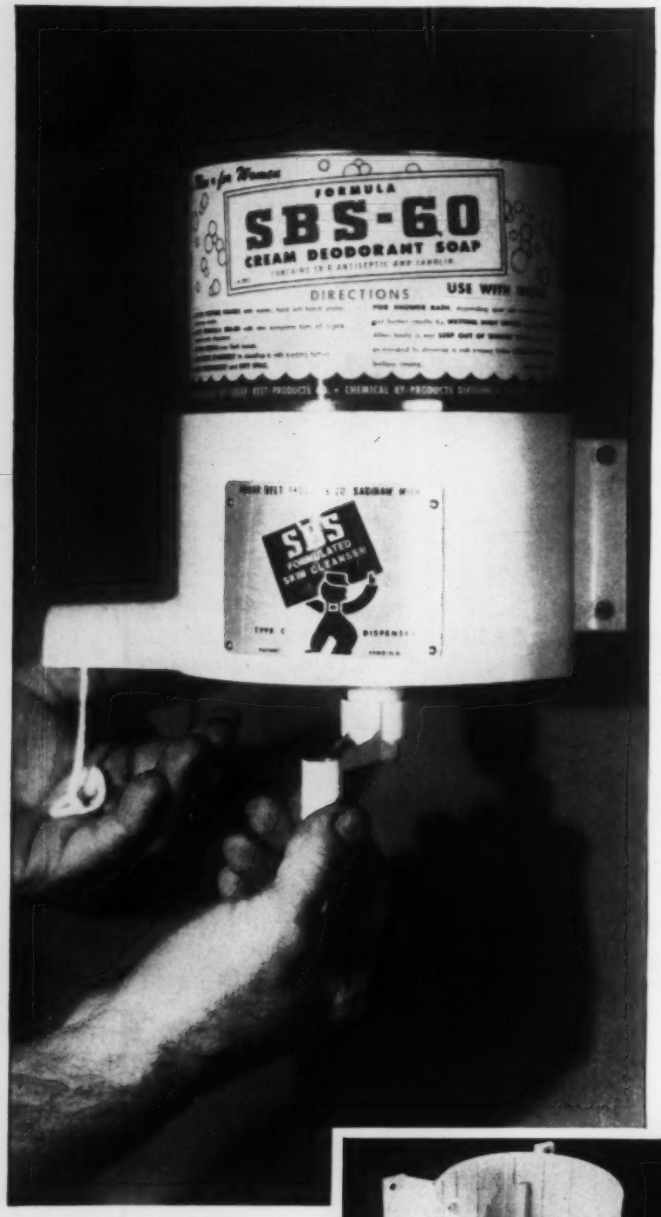
☐ *New information or data as published*

Name _____
Title _____
Company _____
Street _____
City _____ State _____

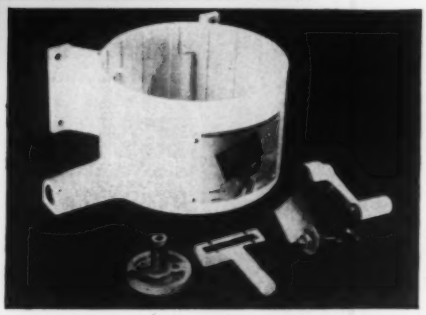
Circle 443 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Soap dispenser housing, crank, plunger, plug and disk are polyvinyl compound molded of rigid Geon by Tube Turns Plastics, Inc., Louisville, Kentucky, for Sugar Beet Products Company, Saginaw, Michigan. Rigid Geon compounds are supplied by B.F.Goodrich Chemical Co.



rigid Geon vinyl makes it rugged, rust-proof and attractive

For good looks, durability and cost savings, too, these soap dispensers for plant and office washrooms are made of high impact rigid Geon vinyl.

These dispensers are durable—they resist breakage—and they won't rust, corrode or react chemically with the soaps they dispense. Total cost is less, since no finishing or painting is required, and colors can be molded in the material.

Rigid Geon is also used for piping, fittings, and extruded shapes. Foam Geon makes cushions and safety padding. Protective coatings for steel, paper, upholstery and flexible wire insulation, too, are made from versatile Geon polyvinyl materials.

For technical information on Geon, write Dept. LO-3, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

NEW OHMITE®

12½ WATT MINIATURE RHEOSTAT

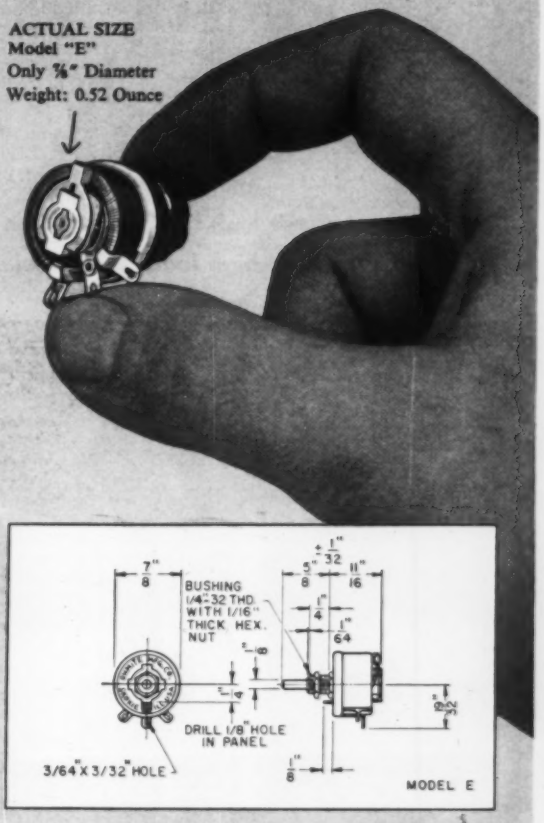
High power handling capability for small size

Newest addition to the Ohmite line of vitreous-enameled rheostats is the new Model "E" miniature 12½-watt rheostat. This new unit is smaller than many one- or two-watt potentiometers. It provides time-tested Ohmite all-ceramic and metal design features for uses where as much as 12½-watt dissipation is required and space is extremely limited. Built to operate at a maximum hot spot temperature rise of 300° C at an ambient of 40° C, Model "E" is also useful for operation at high military ambients, derated linearly to zero at 340° C, attained. Rugged, lasting, power rheostat performance is thus available in such small size that new possibilities in miniaturization and dependability are afforded the apparatus designer.

Like the larger Ohmite rheostats, Model "E" has a ceramic base, and ring-shaped ceramic core. Vitreous enamel holds the turns of wire against shifting, and fastens the base and core together. Also, the Model "E" has a ceramic hub insulating the shaft; a metal-graphite contact; folded spring arm; independent compression spring; slip-ring; a stop directly connected to the shaft. The entire assembly is a miniaturized, dependable version of the time-proven Ohmite power rheostat design. Mounting is by a ¼"—32 threaded bushing. The shaft is ⅛" in diameter. Resistance range: up to 5,000 ohms with 23 stock values; higher values available with OHMICONE inorganic coating. Resistance tolerance: ±10%. Torque: 0.1 to 0.2 pound-inch. A small finger-grip knob, in keeping with the rheostat dimensions, is available.

Special length shafts and bushings, screwdriver shafts, locking type bushing, tandem mountings, enclosures, etc., similar to the variations available on the larger rheostat, can be provided upon specific request.

ACTUAL SIZE
Model "E"
Only ⅝" Diameter
Weight: 0.52 Ounce



INDUSTRY'S MOST COMPLETE LINE OF RHEOSTATS

Now 11 Sizes! — 12½ to 1000 Watts

All sizes available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.

RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS

OHMITE® QUALITY Components

WRITE FOR BULLETIN 157

OHMITE MANUFACTURING COMPANY 3618 Howard Street, Skokie, Illinois

Circle 445 on Page 19

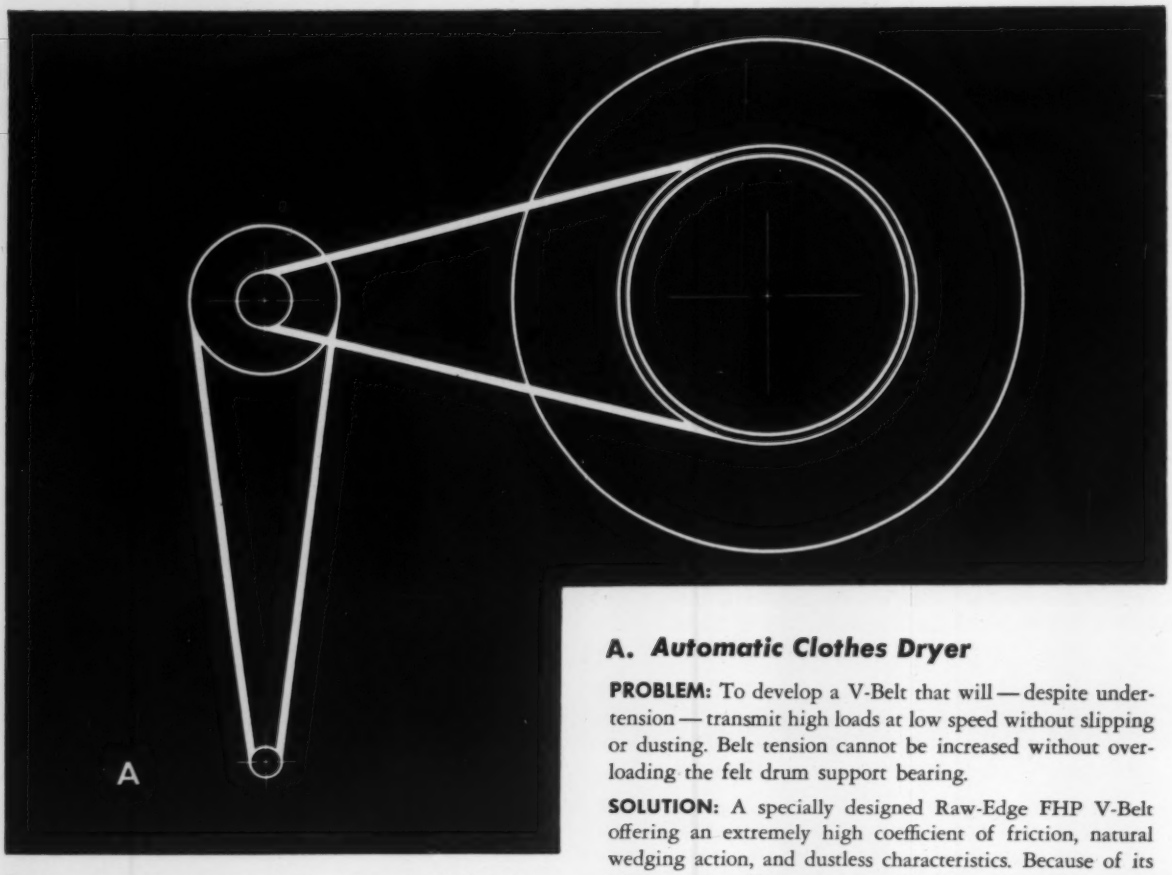
How 3 dissimilar drive problems were solved with special Dayton Raw-Edge FHP V-Belts

THE PROBLEMS:

A. *To transmit high loads using sub-diameter pulleys*

B. *To transmit high loads at variable speeds without vibration*

C. *To transmit high loads with minimum V-Belt tension*

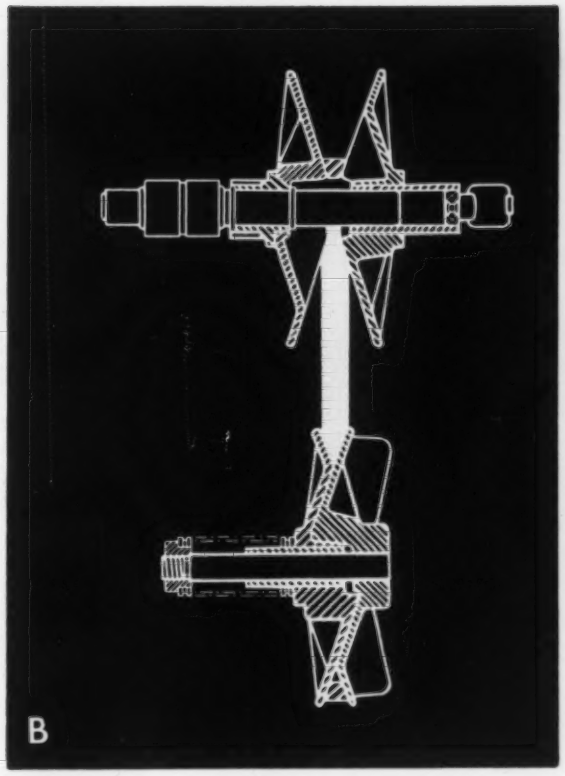


A. *A noteworthy feature of this automatic clothes dryer is the use of a rolled flange on the dryer drum as the final pulley in a 35:1 two-stage reduction drive. The dryer drum is supported by felt bearings.*

A. *Automatic Clothes Dryer*

PROBLEM: To develop a V-Belt that will — despite under-tension — transmit high loads at low speed without slipping or dusting. Belt tension cannot be increased without over-loading the felt drum support bearing.

SOLUTION: A specially designed Raw-Edge FHP V-Belt offering an extremely high coefficient of friction, natural wedging action, and dustless characteristics. Because of its high traction ability, the raw-edge belt will pull the load required without the high tension which would collapse the belt bearing. The inherently dustless characteristic of Raw-Edge V-Belts allows clean operation.



B. *Interdigitary pulleys are employed by a popular home workshop tool to provide an extraordinarily wide range of variable speeds within a limited drive space. By this unique method, the pitch diameter of each pulley can be varied from 1-1/2" to 5-3/16".*

B. *Multi-Purpose Home Workshop Tool*

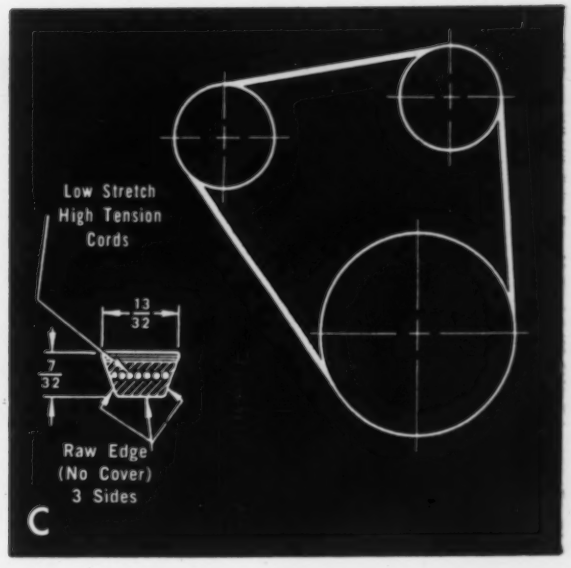
PROBLEM: To transmit heavy loads with interdigitating variable speed pulleys without vibration. The required V-Belt must not take a set due to long periods of idleness and — for safety — must slip under overload.

SOLUTION: A special Raw-Edge Die-Cut V-Belt compounded from special rubbers and fabrics which can be used only in Raw-Edge construction. A full plyed-up section, manufactured under especially close width and length controls, was the solution to this problem. The belt in use

— has the required coefficient of friction to transmit heavy loads and slip under overload

— won't take a set even when stored under tension for long periods

— has the ability to flex over small diameter pulleys



C. *Because of the extreme compactness of a space saving design, this automatic clothes washer employs small diameter pulleys.*

— resists twisting when operating over the interrupted surface of the interdigitary pulleys and thus avoids setting up vibration.

C. *Automatic Clothes Washer*

PROBLEM: Small diameter pulleys with a limited arc of contact caused belt slippage and premature failure in a drive operating at high speed and under heavy loads. Tension adjustment was limited and somewhat inaccessible.

SOLUTION: Employment of a special Raw-Edge Molded FHP V-Belt, with its high coefficient of friction and inherent wedging action, to attain high tractive effort despite the limited arc of contact. As a further refinement, the belt being furnished by Dayton is built with special "low stretch" cords in the strength section to minimize the need for tension adjustment. This solution made redesigning around larger pulleys and heavier belts unnecessary.

Dayton's V-Belt Engineering Service

For help on your drive designs, Dayton Engineers are at your service with the correct V-Belt to fit all your requirements.

To contact one of these V-Belt Design Specialists or for more information on special Raw-Edge FHP V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

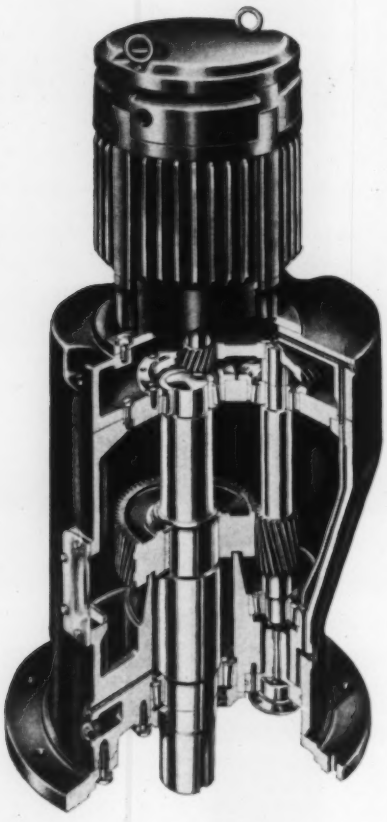
Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.

Circle 446 on Page 19

new for vertical applications



Compact In-line Motoreducer—Here's real design flexibility. And here's simplification of your drive problems—plus substantial savings in space. The new Philadelphia Vertical Motoreducer offers *straight-through* shaft arrangement, with motor and reducer vertically in line. Result: tremendous adaptability where horizontal motor arrangements or right angle drives are difficult to install. Capacity up to 400 hp with ratios to 86.5:1

Designed to give you quality construction in an inexpensive reducer assembly. Just look at the features . . .

Strength. Rugged cast iron frame. Heavy duty bearing support for superior gear performance and longer gear life. Heavy duty output shafting takes most severe overhung load conditions.

Convenience. All standard motor enclosures available. Multi-speed motors or variable-speed drives can be supplied to provide economical in-motion speed control.

Easy maintenance. First reduction pinion and gear easily accessible for quick replacement. Changes in unit output speed quickly made with stock helical gear sets.

Trouble-free service. Rugged crown-shaved helical gearing assures long, efficient service life. Two-way seals seal out dirt and atmospheric contaminants. Unique Philadelphia dry well construction positively prevents oil leakage down output shaft.

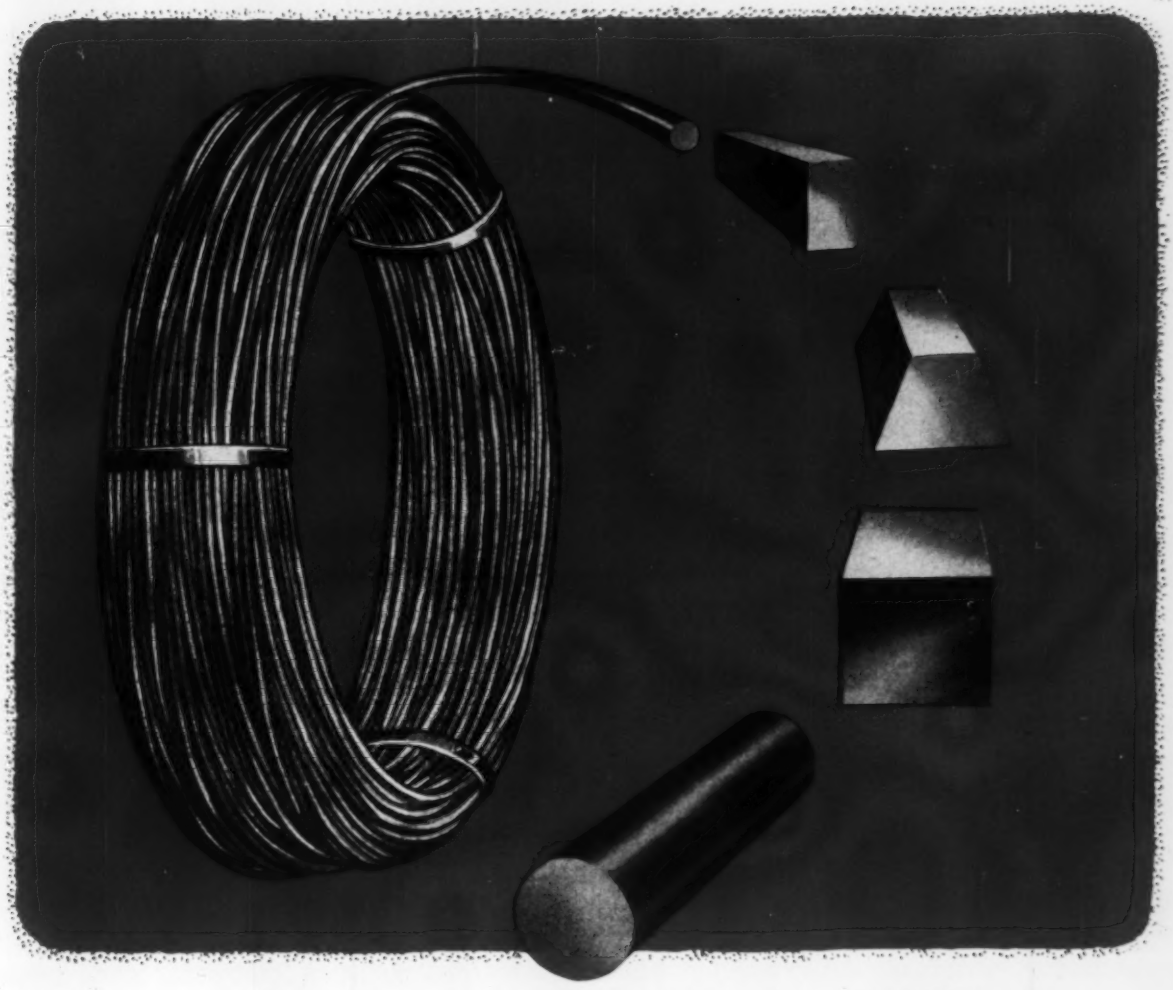
Get full details—no obligation. Write for our new Catalog A-27 or call your nearest Phillie Gear Office. Philadelphia Gear Works, Erie Ave. and G Street, Philadelphia 34, Pa.

Offices in Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

phillie gear®

Circle 447 on Page 19

For Your Steel Requirements!



Specify Reliance SPECIAL STEELS

Steel purchasers can't guess . . . they've got to know absolutely that the steel they specify will meet particular requirements. Too much is at stake in the manufacture of any product to permit guesswork on the quality of steel from which the product is being made. It is this quality that determines the excellence of the final result.

That is why we, at Reliance, can place our modern plant at your service to provide special quality steels to meet your specifications. Our cold finished steel, produced on modern equipment by experienced personnel, must meet rigid inspection and quality control checks during every step of production by our chemical and metallurgical laboratory staff. Our steel in rounds, squares, flats or special shape sections in wire sizes .020 x .020 to ½ x $\frac{5}{16}$ in coils or cut to length all undergo rigid Eaton Reliance inspections regardless of type: cold drawn, cold rolled, centerless ground, carbon, alloy, stainless, K-Monel, bronze or aluminum.

Our steel mill produces ball and roller bearing quality, key stock, cold heading quality spring steel whose surface tolerance, physical specifications and machineability must meet specific requirements. Let us help cut your production costs with fine quality steel. Write for further information.

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PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Circle 448 on Page 19

For fast, cold sandwich bonding ...3M Adhesive EC-1357

NIP ROLLER OR COLD PRESS COMPLETES STRONG, LIGHTWEIGHT SANDWICH PANELS WITH EC-1357. YOU NEED NO HEATED PRESSES.

Gain the speed and economy of cold bonding! Fabricate sandwich panels for non-load bearing uses with 3M Adhesive EC-1357.

This high-strength, flexible adhesive bonds sandwich panels without clamps or heated presses. You force-dry the solvent out of the adhesive before bonding. Cold press or nip roller finishes the job. You get maximum immediate strength. And EC-1357 builds up even more strength with age as it cures at room temperatures.

Because it is dark in color, EC-1357 absorbs drying heat fast. Thus it cuts production time, allows continuous movement from adhesive spraying to finished panel. EC-1357 resists moisture and normal temperatures, too. For load-bearing panels, investigate 3M Adhesive EC-1177.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature, write on your company letterhead to:3M,Dept. C-5. 417 Piquette Ave., Detroit 2, Mich.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY · ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

Circle 449 on Page 19

What every designer should know about

FACE GEARS for Angular Drives

FACE GEARS have distinct advantages which the designer should know. They can be spur or helical, "on-center" or "off-center." The mating members are pinions. Both are generated on Fellows Gear Shapers by cutters having involute teeth.

Utilization of face gears results in a simple, compact design that can be economically manufactured and assembled.

Consider all these advantages:

- quality cutting at low cost
- easier and lower cost assembly
- no appreciable thrust
- pairing for reversal of direction
- tooth bearing not affected by axial displacement of pinion

GET ALL THE FACTS:

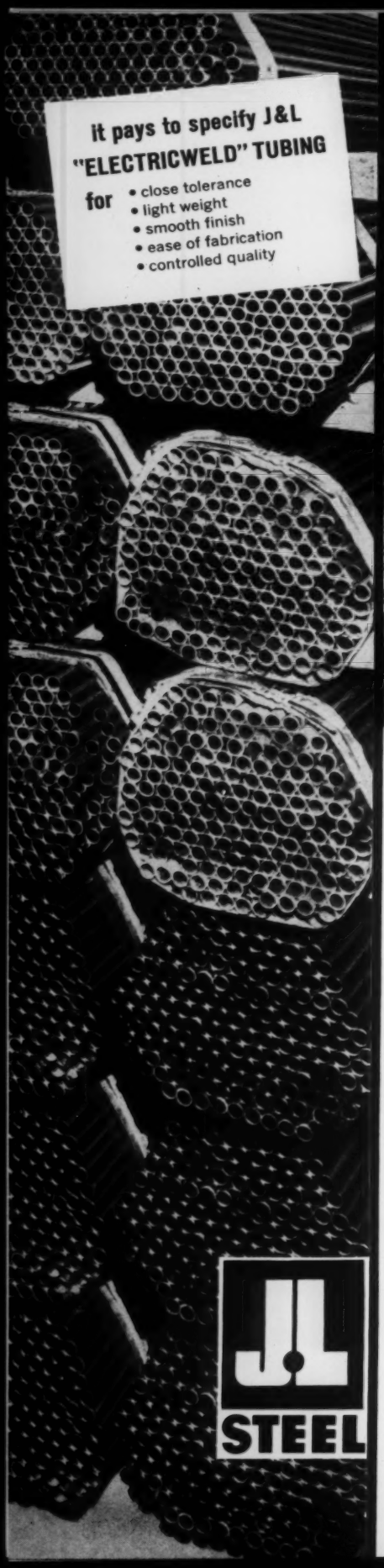
Information on the design and cutting of Face Gears is free for the asking. Just write to:

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont

Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

Circle 450 on Page 19



"Electricweld tubing gives us greater strength with lighter weight" ...says SHOPSMITH manufacturer

The Magna Power Tool Corporation has been using J&L's light wall tubing for Shopsmith ways since 1947. These twin tube mounts make possible the versatility of these popular multi-purpose home workshops. "Electricweld" precision tubing is used for the rigid straightness to .003" tolerance on diameter. Performance has been so satisfactory that Magna Power Tool Corporation now has eight applications for "Electricweld" tubing.

"Electricweld" tubing may be the answer to *your* design and manufacturing problems. Your nearby J&L representative can recommend the exact shape, size, gage and grade of tubing for your products. He frequently can reduce your costs, improve your product. Call him today, or write for information based on your specific requirements to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

Circle 451 on Page 19

SAVE with Aetna BEARINGS

DO YOU HAVE THE NEW AETNA GENERAL CATALOG AND ENGINEERING MANUAL?

Contains valuable engineering data, formulas, tables, design application drawings, shaft and housing fits, lubrication helps, etc. in a compact, readily accessible unit.

Secure your copy by phoning your local representative listed in your Classified Phone Book or write direct.

SAVE design adjustments and compromises

The Aetna line of quality precision bearings is so complete and diversified that within it there is undoubtedly the exact bearing, with the exact specifications, required for your design. No need to modify or change your design—no need to specify characteristics which require extra-cost handling.

This is especially true of Thrust Bearings—a field in which Aetna is the acknowledged leader—with a broad line of sizes and load ratings to meet practically all requirements from stock.

SAVE assembly costs

Precision dimensions held to exact tolerances guarantee press fit without effort or adjustment. Bearings received in perfect, factory-fresh condition, require no cleaning—no checking or inspection. Simply remove from carton, strip off the protective wrapper and install.

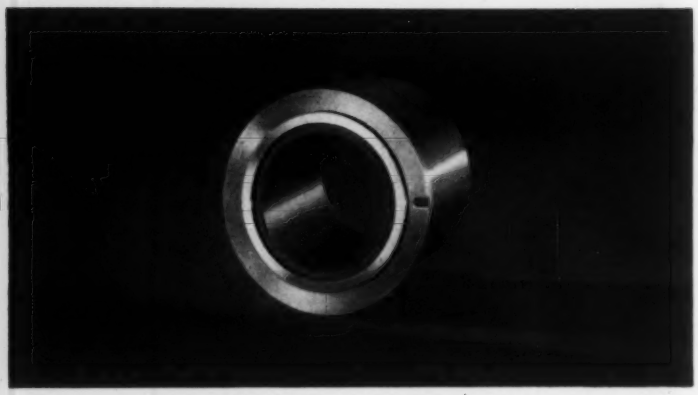
SAVE repair and replacement losses

Aetna bearings stand up under the loads and service for which they are designed—give long hours of perfect anti-friction performance—require no attention beyond periodic lubrication—seal out dirt, dust, grit and atmospheric impurities—and permit your equipment to deliver the fine, trouble-free performance which you have built into it.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

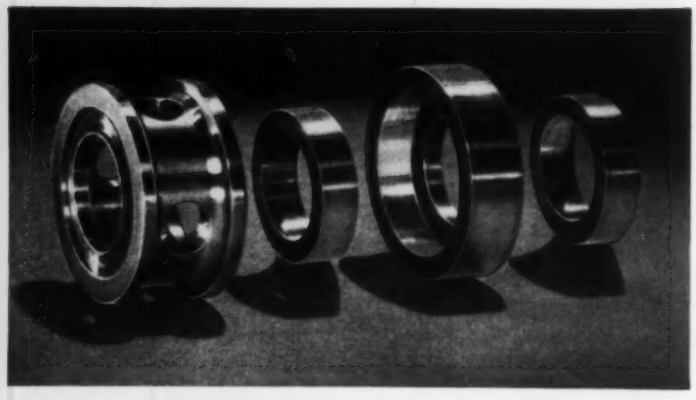
Aetna ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916



SINGLE BUSHING TYPE Floating Ring Seal

Seal Any Medium—Even Corrosive Media ... with Koppers Floating Ring Seal

MULTIPLE RING TYPE Floating Ring Seal (assembled)



FLOATING RING SEAL Basic Elements: Lantern Ring, Floating Ring, and Spacer Diaphragm. As sealing needs dictate, floating rings and spacer diaphragms are added. Seals are carbon, plastics, ceramics or steel, as applications require.

The Only "No Maintenance" Seal for Rotating, Oscillating and Reciprocating Motion

Koppers' precise, efficient Floating Ring Seal assures long seal life, low leakage, reduced wear, less power consumption, and decreased operating costs.

It seals at high temperatures and at pressures up to, and for some conditions even above, 2000 psi. Inspection has shown that after 10,000 hours of operation, ring and spindle wear can be negligible. For water at 500° F. and 1200 psig with a 5/8" spindle, leakage is only one to two pounds per hour. Frictional power requirements are virtually zero, and Koppers' design reduces radial frictional restraint. Sealing members adapt to changes in the shaft's position.

Applicable to valve spindles, pumps, atomic reactor spindles and many other similar installations, Koppers Floating Ring Seal gives efficient, low-cost service for the sealing of all types of fluids under widely varying conditions of temperature and pressure.

For additional information, write to: KOPPERS COMPANY, INC., Piston Ring and Seal Department, 2305 Hamburg Street, Baltimore 3, Maryland.

KOPPERS

MECHANICAL SHAFT SEALS

Engineered Products sold with *Service*

Circle 453 on Page 19

NEW...YET BILLION-PROVED... VALFORGINGS TO IMPROVE PARTS STRENGTH, CUT COSTS

Here is a full-size cross-section of a VALFORGING... an extruded steel forging made by the Valve Division. See how the grain flow lines are continuous and symmetrical with the outside contour. This means added strength and higher impact resistance in any large-head, small-shaft part.

VALFORGINGS come to you precision-forged from any grade of steel you specify, and with practically the finished dimensions of the part. High-cost machining and scrap generation are greatly reduced. The flawless structure of a VALFORGING assures dependability of the finished part and eliminates manufacturing scrap losses resulting from the uncovering of internal defects.

You can confidently switch to VALFORGINGS ... more than one billion have already been produced by the Valve Division as engine valves for the cost-alert automotive industry.

To know *all* about VALFORGINGS, tell us when a sales engineer from the Valve Division may call on you.

Valve Division ***Thompson Products, Inc.***

DEPT. MD-558 • 1455 EAST 185th STREET • CLEVELAND 10, OHIO

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Frank W. Springsteen, left, senior planning delineator, points out to Joseph F. Reilly, director of the bureau of office services in N. Y. State's department of public works, the high quality and contrast of an 11″ x 17″ reduction run off on an offset duplicator from a paper master prepared xerographically from an original 22″ x 34″ highway drawing.

New York State is saving $120,000 yearly on

- HIGHWAY CONSTRUCTION PLANS
- SPECIFICATION BOOKS
- PREPRINTED FORMS OF ALL KINDS

Xerography and offset duplicating are saving the New York State department of public works $120,000 yearly. This is an amount expected to grow, since the state is finding more and more uses for the versatility of xerography, a clean, fast, dry, electrostatic process copying —in enlarged, reduced, or the same size—anything written, printed, typed, or drawn.

The New York State department of public works uses XeroX® Model 1218 copying equipment in the quantity reproduction of highway construction plans for bidders and contractors, specification books, and preprinted forms of all kinds.

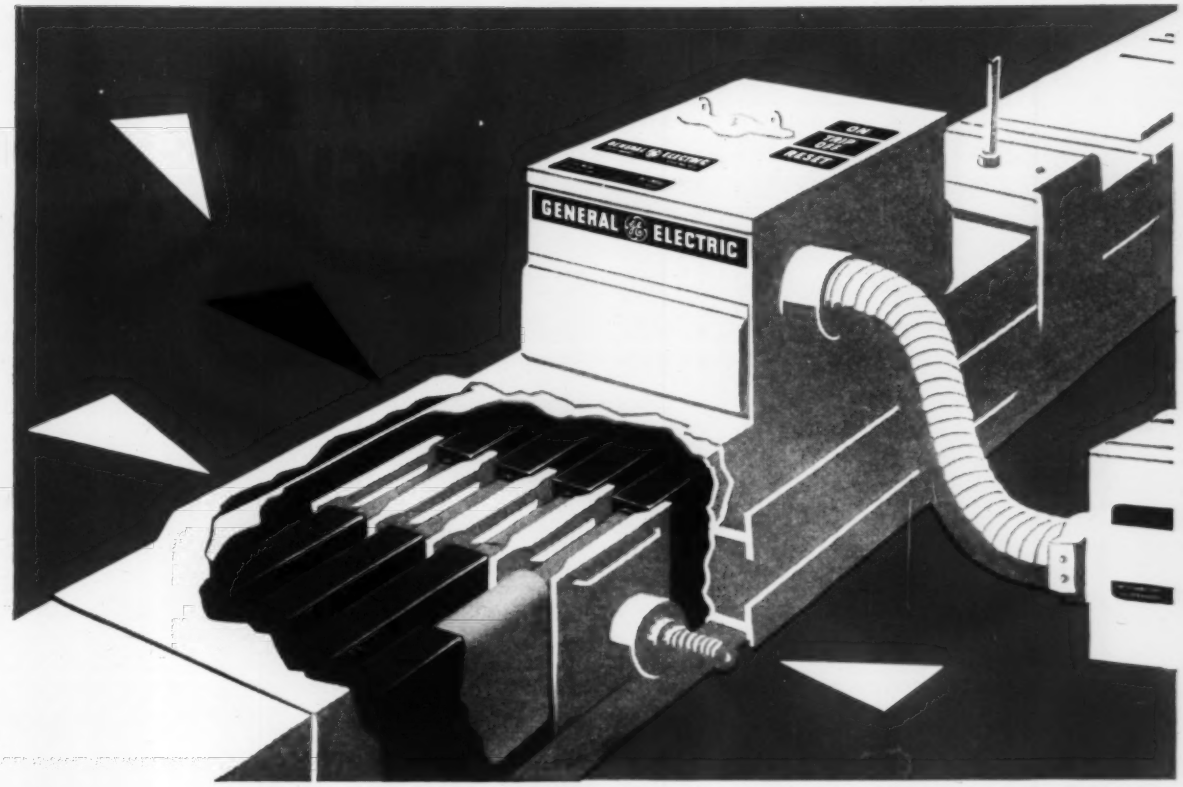
This equipment reduces, with fine legibility, drawings as large as 24″ x 36″ onto the 12″ x 18″ confines of an offset paper master, from which multiple copies are run off on an offset duplicator.

The handier print size achieves economies in space, time, materials, handling, and postage. Hand shearing and hand collating are eliminated as well as a great deal of proofreading. Portability and lower cost of the new prints have increased demand by 25%.

Write us for proof-of-performance folder showing how New York State is speeding paperwork and is saving $120,000 yearly by xerography. Haloid XeroX Inc., 58-186X Haloid Street, Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities.

HALOID XEROX®

Circle 455 on Page 19



When Enjay Butyl is used as continuous insulation of tubular aluminum conductors, traveling arcs are virtually eliminated, plug outlets are essentially dead-front.

ENJAY BUTYL

helps keep costs low in new Aluminum Busway!

Enjay Butyl is extruded over the full length of the conductors used in General Electric's new Type DE Busway, the first busway designed specifically for aluminum. This new busway incorporates all 22 features that engineers consider important in busway design, yet it is up to 30% smaller and 50% lighter than other busways of comparable rating.

Enjay Butyl rubber is ideal for use as continuous insulation of tubular conductors because of its inherent resistance to ozone and to heat aging. Add Butyl's excellent electrical properties, its vulcanizability and the fact that it is the *lowest cost* rubber on the market—and you'll understand why it was chosen above all other rubbers to do this job.

Every day manufacturers are discovering new ways to use economical Butyl. Find out how Enjay Butyl rubber can cut production costs for you. For further information and expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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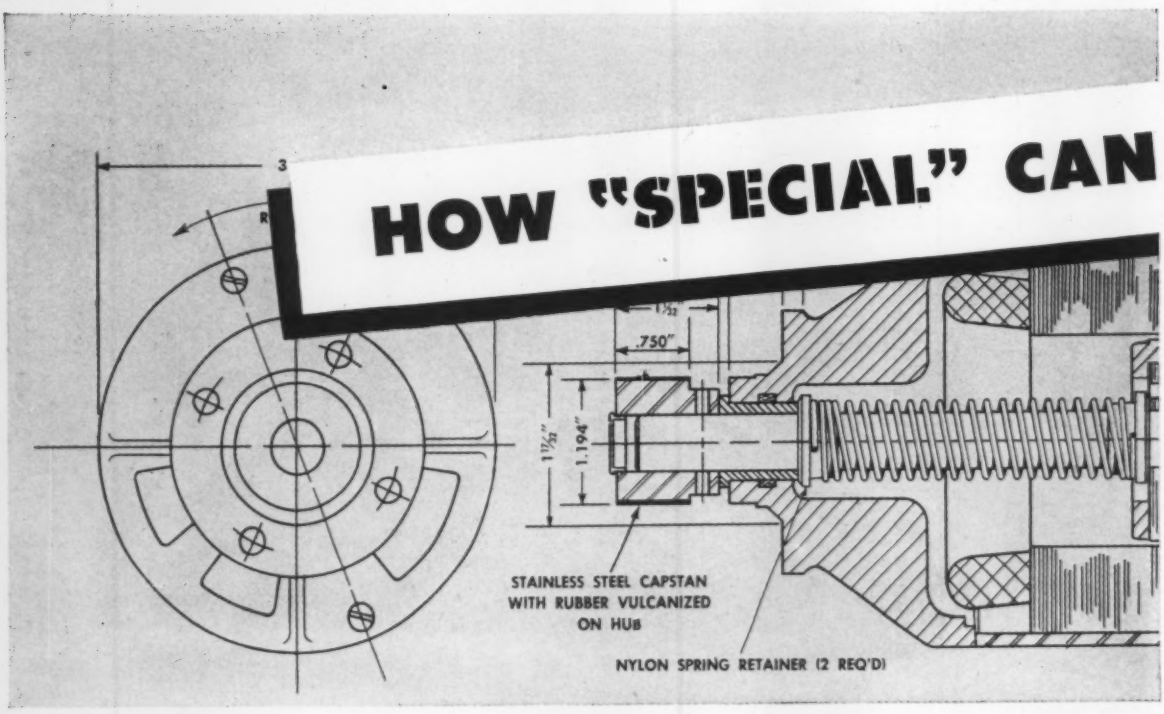


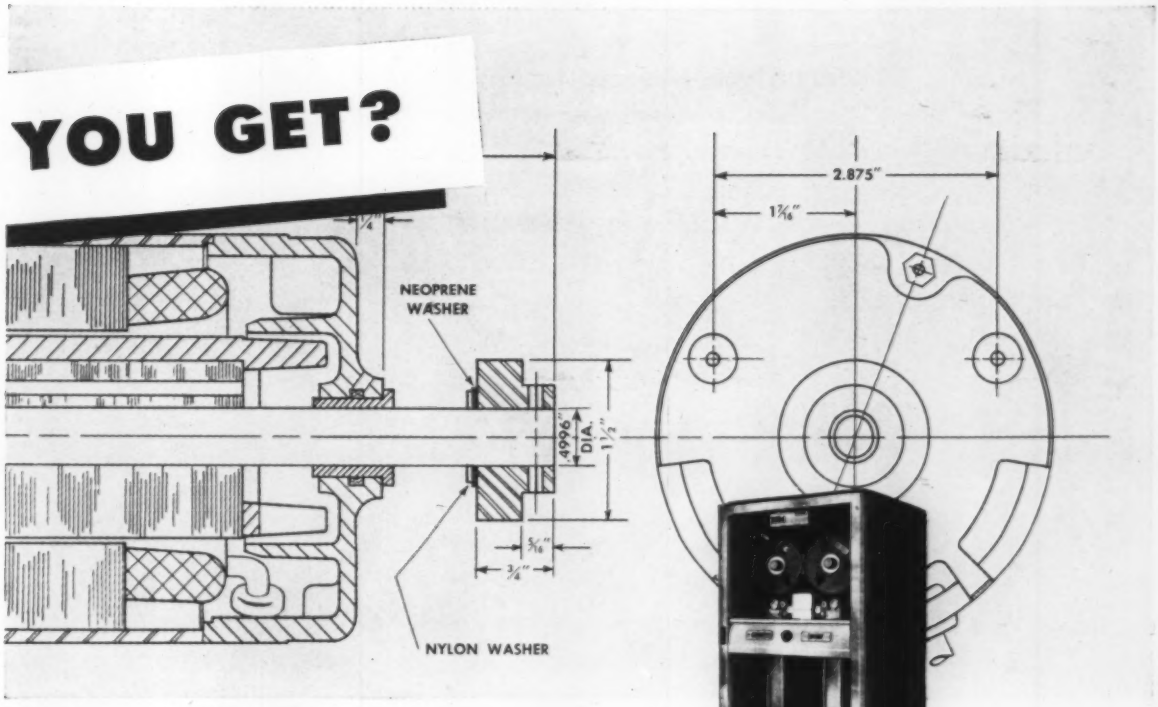
SPECIAL ROBBINS capstan motors function

SPECIFICATIONS

Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.

Robbins & Myers builds motors from 1/200 to 200 horsepower

YOU GET?



& MYERS
accomplish unique in IBM'S 727 magnetic tape unit!

SHAFT ROTATES AND MOVES AXIALLY

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units —driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

R&M

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Circle 457 on Page 19

creative designing calls for an open mind

Leonardo Da Vinci's design for an odometer

Model courtesy of IBM

EVEN DA VINCI'S ODOMETER COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

An SKF engineer can afford to concentrate on your bearing problem rather than his own product line—because the SKF line includes all four types of ball and roller bearings in many thousands of sizes. This gives him the kind of flexibility he needs to keep an open mind on any bearing problem. Give your problem to SKF and see. 7836

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC. PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

Save 27% or more in cost...

NEW

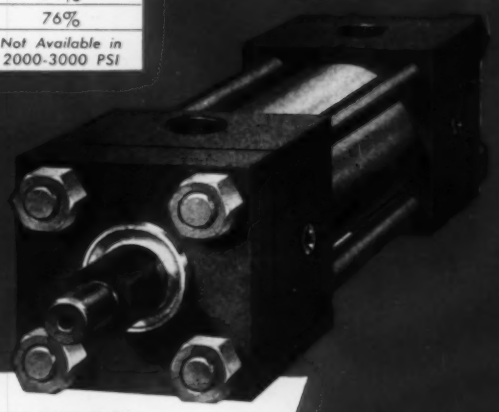
Miller

"JOB RATED"

HYDRAULIC CYLINDER LINE

JOB RATED, MODEL " J "			
BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½*	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.



SEAL FAILURE MEANS CYLINDER FAILURE!

1. *No seal made of synthetic rubber is compatible with even 50% of available, commercial, petroleum base hydraulic fluids.*

MILLER Uses All Teflon* Seals to Eliminate External Oil Leakage because Teflon is impervious to all known hydraulic fluids, even fire-resistant types.

TEFLON SHEF SEAL At Tubing Ends

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON Seals On Piston Rod And Bushing

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON Seals On Ball Check And Adjusting Screw

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

MILLER Uses Resin-Impregnated Leather Piston Cup Seals because they are compatible with petroleum base fluids and some fire-resistant types. Teflon cups available at small extra cost.

2. *Nicked or scored piston rods cause seal failure*

MILLER Uses Case-Hardened Chrome-Plated Piston Rods because they prevent nicks, scoring and rust.

NOW! . . . You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program as the Power-Packed Line (2 hours if necessary—3 days normal).

* du Pont trademark for polytetrafluoroethylene resin which withstands temperatures from −100° F. to +500° F. and all hydraulic fluids.

OTHER MILLER QUALITY FEATURES

- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Precision Honed Barrels

Circle 459 on Page 19

MILLER FLUID POWER

DIVISION OF TUCK-WEEDY CORPORATION

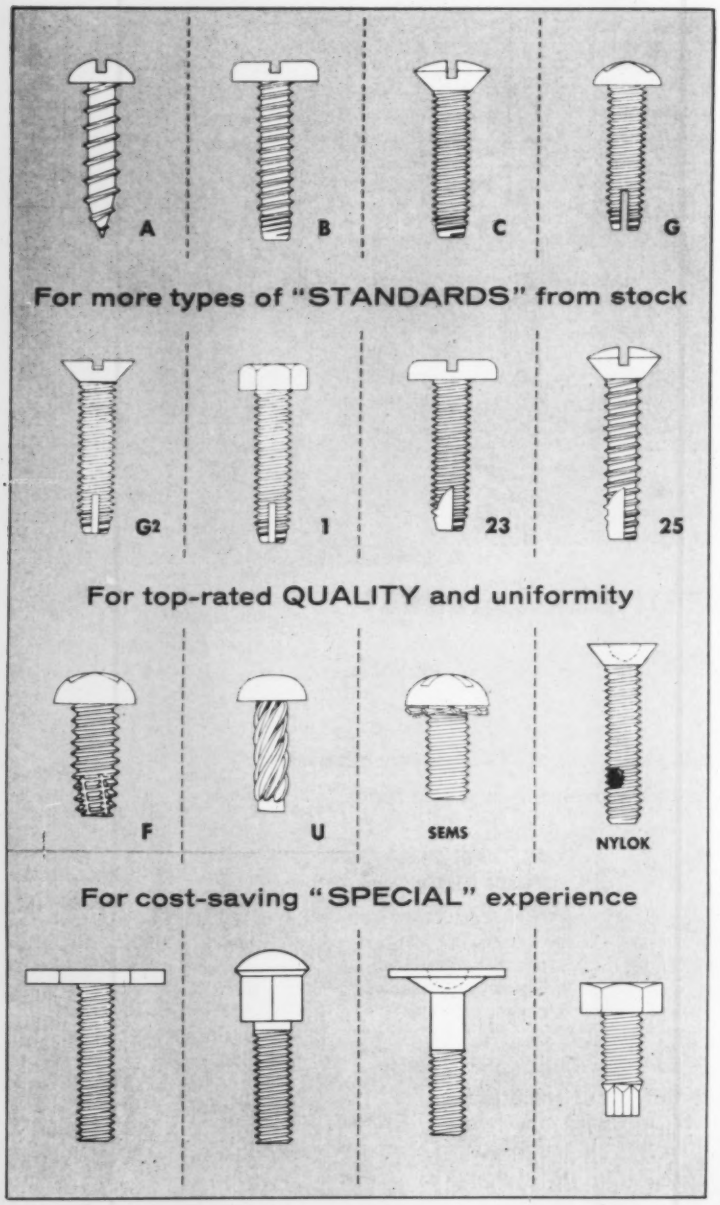
2006 N. Hawthorne Ave. Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

Count on *Continental* to show you why

you can measure the difference in assembly dollars

when you use the right type for the job



Which fasteners will serve best and save most in your assemblies? Many types of screws look much alike, but the difference between the right and wrong choice for your job can often make a big difference in assembly costs.

Since Continental makes and supplies *all* types, their recommendations are unbiased. They can tell you if you should be using some "standard" you have overlooked. Or, if a "special" will save you most, you can rely on Continental's specialized experience to design and produce it at the lowest possible cost.

CHECK YOUR ASSEMBLIES

Find out where Continental's cost-saving ideas can cut your assembly costs. Talk to a Continental Assembly Specialist. For prompt service, write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

MEMBER
SCREW RESEARCH ASSOCIATION

. . . you can count on

CONTINENTAL
HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING • THREAD CUTTING • SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

Circle 460 on Page 19

(Advertisement)

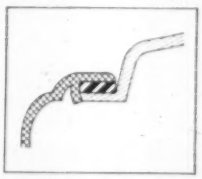
Technical data for gasket design and selection

NUMBER THREE

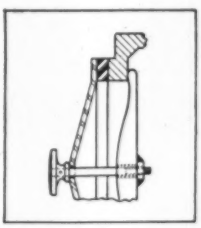
Gasket materials for low-cost flanges

Sealing of stamped or other low-cost flanges usually requires a gasket material that will seal irregular surfaces under fairly low bolting pressures.

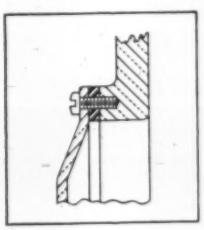
Such sealing jobs can be handled with Armstrong cork-and-rubber compositions, which are available in a wide range of compressibilities.



Three typical applications for these materials are shown here. Figure 1 is an automotive taillight assembly. A cork-and-sponged butyl composition provides a weather-tight seal, conforming to the normal irregularities in the plastic lens and die-cast rim.



In Figure 2, another cork-and-rubber compound provides an effective seal for a stamped hand-hold cover. Opening and closing of the cover are facilitated because the cork-and-rubber resists fatigue.



In the waterproof electric motor housing in Figure 3, an Armstrong cork-and-rubber composition accommodates surface irregularities in the stamped cover, yet stands up under exposure.

How to use plaster of Paris and compressed air to check oil leaks on lightweight flanges

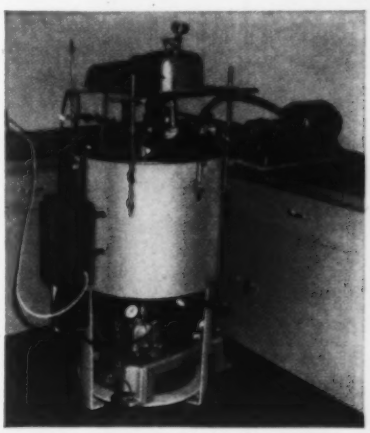
Effective sealing of stamped flanges is complicated by their normal surface irregularities and by a tendency for these light flanges to distort under relatively low bolt loads. The obvious economies offered by these lightweight components have, however, led to their increasing use.

Designers who have experienced difficulty with gasket leaks on light flanges may find test methods developed by Armstrong engineers useful in evaluating the various factors that can contribute to the trouble.

Two such tests—both using standard automotive oil pans—are shown here.

The picture above shows an air leakage test. The oil pan is gasketed and bolted to a steel plate, and strain gauges are taped to it. Air at 25 psi is pumped into the pan and locked there. Leakage is sensed and continuously recorded in terms of reduction in stress. To increase the sensitivity of the test, the volume of air is reduced with a plaster mold.

The results of the air leakage test are checked with a simulated service test shown at the right. Here, a gasketed oil pan is completely filled with oil at 250° F. and kept under constant pressure of 25 psi. Any leakage is visually observed.



These tests check the relative sealing efficiency of different kinds of gasket materials, and the effect of changes in width or thickness of the material. In addition, of course, the relative effect of variations in bolt loads, or changes in the number, size, and spacing of bolts can also be determined.

Engineering research on problems of gasket performance, design, and selection is a full-time activity at Armstrong. The results of this work may be of help with gasket problems you may have. We'll be glad to make suggestions if you send details to us.

For your copy of our gasket materials catalog, write Armstrong Cork Company, Industrial Division, 7105 Dean St., Lancaster, Pa.

Armstrong GASKET MATERIALS

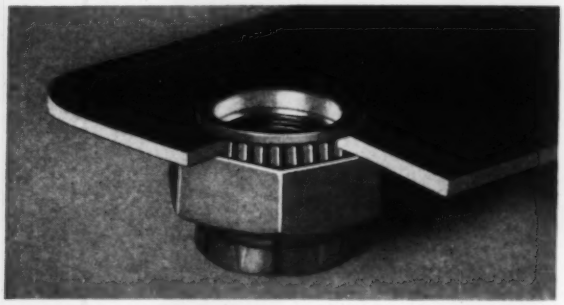
. . . used wherever performance counts

Circle 461 on Page 19

1. Hole in your subassembly accommodates the knurled shank of the FLEXLOC. The holding fixture is fitted with an inexpensive FLEXLOC dolly tip.

2 Fit the knurled shank of the nut into the hole. Your production engineers can easily design fixtures to make this operation completely automatic.

3. Clinch the shank to the subassembly with a single stroke. This electric press is equipped with a FLEXLOC punch tip which also can be used with an ordinary hammer.



4. Cutaway view shows how FLEXLOC becomes an integral part of the completed assembly. FLEXLOC functions as a tapped hole—one that will lock a screw securely in place.

FLEXLOC self-locking clinch nuts simplify fastening to thin-section materials

Drill a hole in any thin-section material, insert the knurled shank of a FLEXLOC, clinch it, and you have a permanently anchored self-locking nut as an integral part of the material. In addition to positive self-locking, you also get the advantage of the hollow shank as a guide for the screw—a timesaver in blind mounting operations. And you can take the assembly apart as often as necessary without affecting the locking action of the nut.

Simplify production operations and increase product reliability by using FLEXLOC self-locking clinch nuts in place of cage nuts, anchor nuts or weld nuts. FLEXLOCS are easy to install, require no riveting or welding, no separate locking devices. They serve as locknuts or stop nuts, gripping the screw securely wherever wrenching stops. Locking efficiency is unaffected by vibration, heat, moisture or lubricants.

Standard FLEXLOC self-locking clinch nuts are available in steel, brass, aluminum or stainless in sizes from #0 to ¼ in. for use in materials from $\frac{1}{32}$ through $\frac{5}{16}$ in. thick. See your authorized SPS distributor for complete information. Or write us for literature and samples. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

hiRf
High Reliability factor

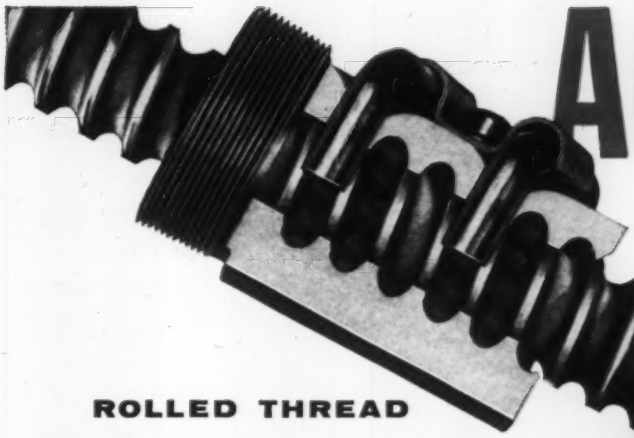
At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic stresses. By using SPS fasteners in your assemblies, you help assure overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.



ACTUATE

MORE EASILY... EFFICIENTLY... ECONOMICALLY

ROLLED THREAD

SAGINAW b/b SCREWS

Make Your Product

- easier to produce
- easier to operate
- easier to sell

The secret lies in a new anti-friction principle—steel balls recirculating in closed-circuit raceways. They permit Saginaw b/b Screws to change rotary motion into linear motion with over 90% efficiency and 4/5 less torque than Acme screws. Result: Saginaw b/b Screws save manual effort or electrical power; they permit space savings—smaller motors and gear boxes; they provide more dependable performance; more precise positioning; more temperature tolerance and more lubrication latitude.

SEVEN STANDARD SIZES REDUCE COSTS

Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅜ inches to 10 inches diameter.

MANY TYPICAL APPLICATIONS

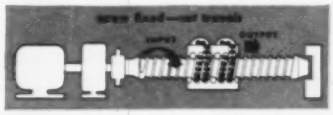
Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION

Let Saginaw's experienced engineers help solve your special application problems. Just write or phone us—no obligation.

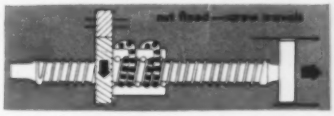
Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS



When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



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or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 5MD, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

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COMPANY _____ TITLE _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Saginaw

ROLLED THREAD ball bearing Screw

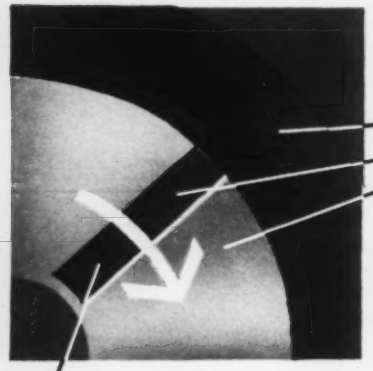
SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

Circle 463 on Page 19

GRAPHITAR®

(CARBON-GRAPHITE)

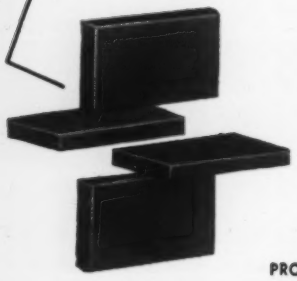
against

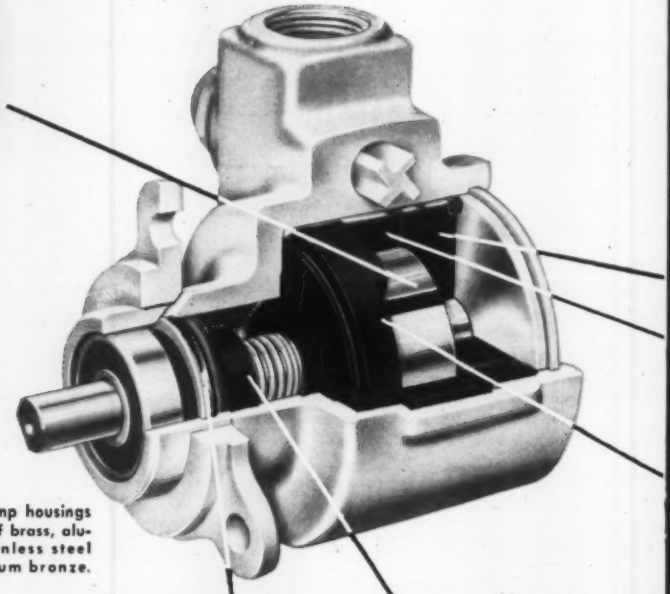


GRAPHITAR LINER

GRAPHITAR VANE

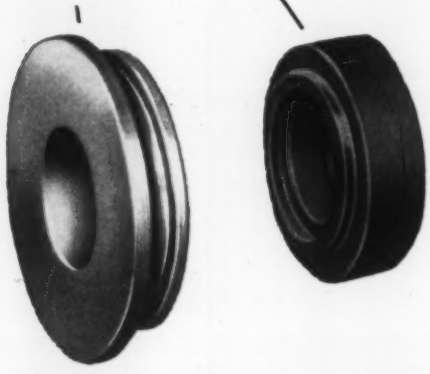
STAINLESS STEEL ROTOR





PROCON pump housings are forged of brass, aluminum, stainless steel and aluminum bronze.

GRAMIX seal-ring retainer



GRAPHITAR is ideal for high-stress parts . . . pistons, cylinder liners, bearings and seals . . . because it's so resistant to temperature change and wear. Chemicals, concentrated acids, highly corrosive ammonia have little effect on GRAPHITAR . . . in fact, may even serve as lubricants to GRAPHITAR parts. GRAPHITAR is lightweight, can be produced economically in most any size and shape, and held to tolerances as close as .0005". Perhaps self-lubricating GRAPHITAR parts can improve the efficiency of your products. For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

THE UNITED STATES

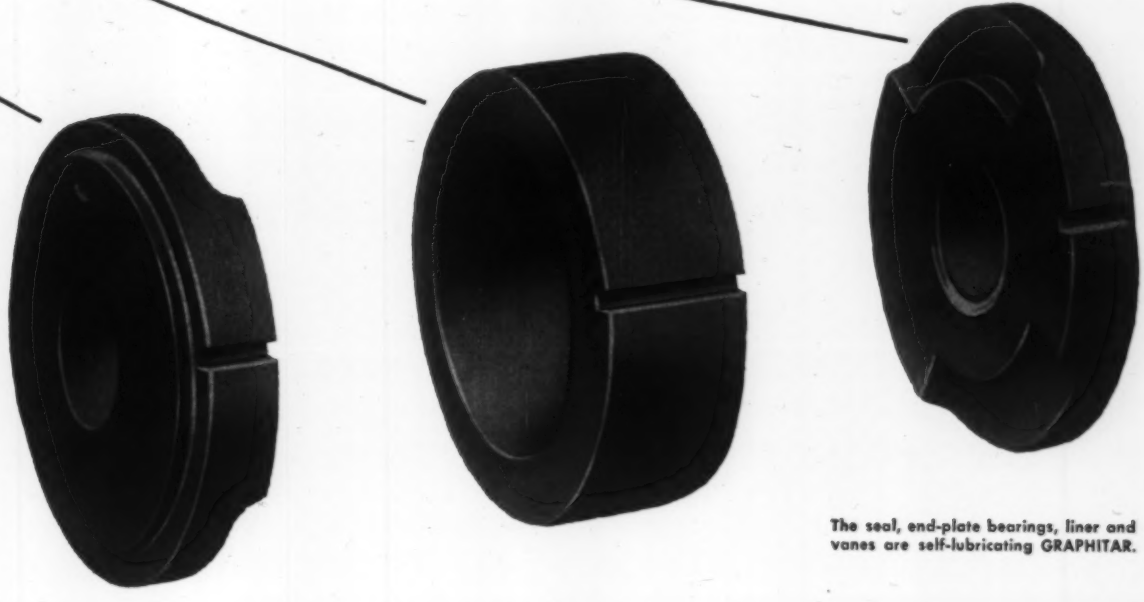
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

running GRAPHITAR®

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*

10¢ dropped in a beverage machine in Minneapolis actuates a pump that fills a paper cup with syrup and carbonated water; a Utah dentist flicks a switch that starts a vacuum pump used in molding dentures; in a manual training school in North Carolina, a pump circulates the ammonia in a blueprint machine.

Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.



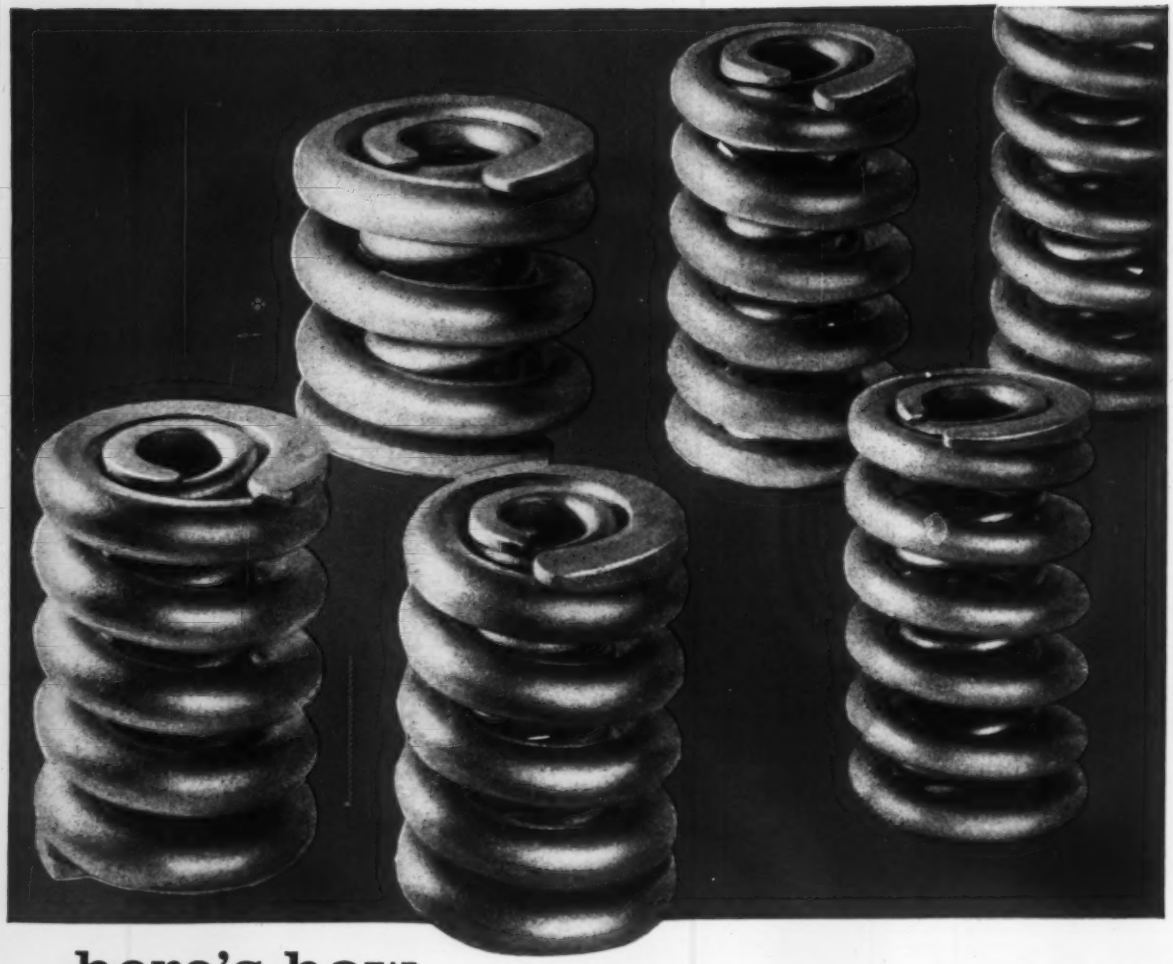
The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-256-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 464 on Page 19



here's how Crucible Fatigue-Resistant Springs are made stronger to last longer

Crucible *fatigue-resistant* springs outlast conventional heavy-duty coil springs many times. That's because they are shot peened.

Shot peening actually makes the springs stronger by imposing a compressive stress on the surface of the spring that offsets some of the working stresses set up in service. Further, shot peening conditions the surface. The high intensity peening eliminates stress concentration points that could lead to failure of a conventional spring.

Moreover, when you buy Crucible springs, you employ all of Crucible's many years of experience and metallurgical know-how in fine steelmaking – from ore to finished spring. Good springs demand the best in specialty steels. During manufacture, quality checks are made continuously. And a final magnetic test may be given if desired.

When you have a requirement for a spring that must endure rugged operating conditions, secure the built-in advantages of Crucible *fatigue-resistant* springs. And for technical assistance in designing or selecting heavy-duty springs, don't hesitate to consult with Crucible's spring specialists. For a free copy of a handbook on "Coil Spring Design," write to *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE HEAVY-DUTY COIL SPRINGS

Circle 465 on Page 19

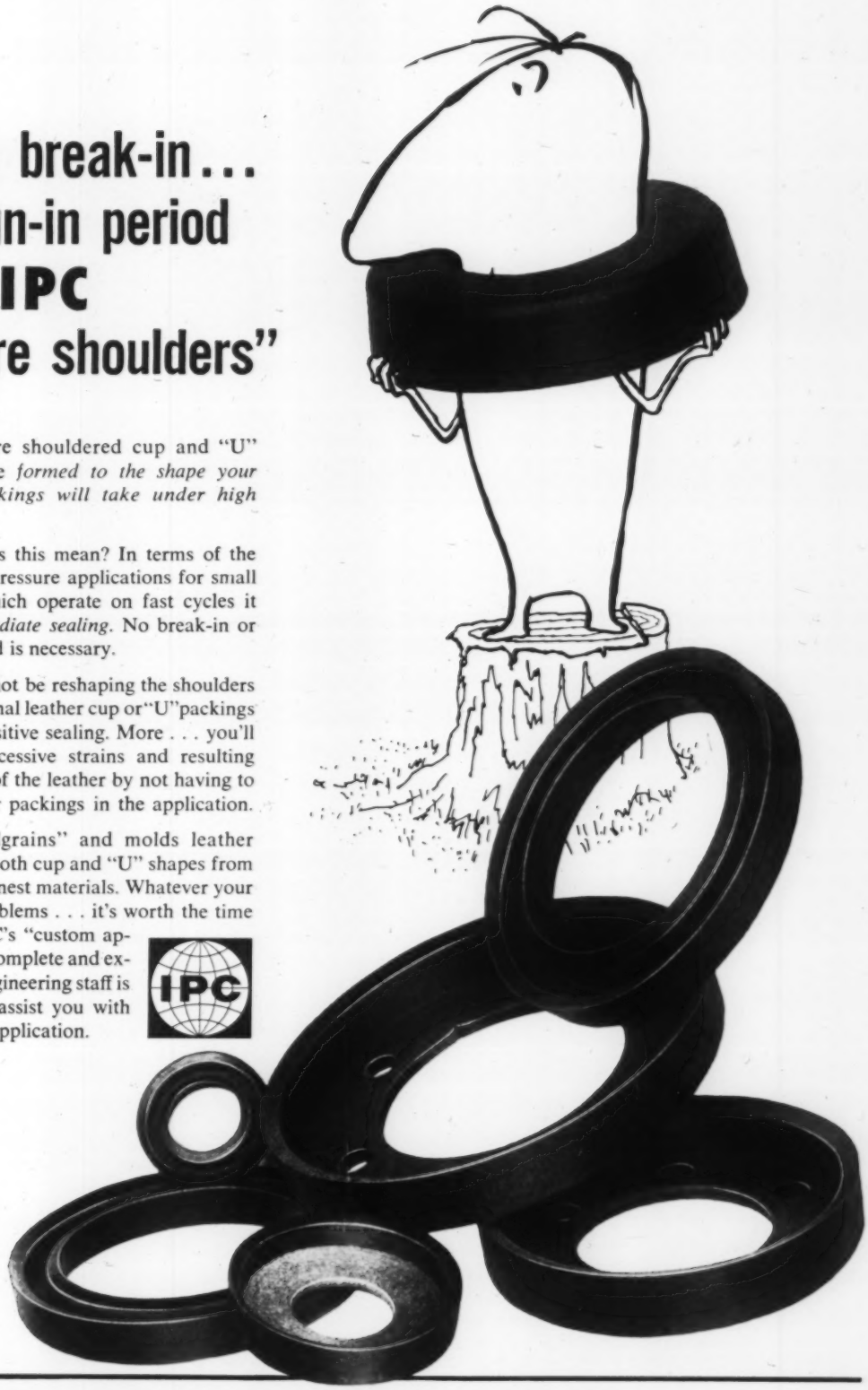
No break-in... no run-in period with IPC "square shoulders"

IPC's square shouldered cup and "U" packings are *formed to the shape your leather packings will take under high pressure.*

What does this mean? In terms of the many high pressure applications for small cylinders which operate on fast cycles it means *immediate sealing.* No break-in or run-in period is necessary.

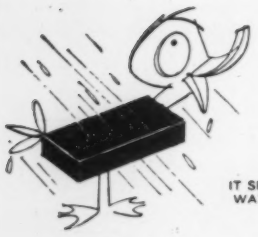
You will not be reshaping the shoulders of conventional leather cup or "U" packings to assure positive sealing. More . . . you'll eliminate excessive strains and resulting weaknesses of the leather by not having to reshape your packings in the application.

IPC "endgrains" and molds leather packings in both cup and "U" shapes from the world's finest materials. Whatever your packings problems . . . it's worth the time to check IPC's "custom approach." A complete and experienced engineering staff is available to assist you with any sealing application.



Packings
Oil Seals
Precision Molding

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire P3



How would you use... SOLID RUBBER this soft?

To help you decide, send for the booklet "How Designers Are Using The Softest Solid Rubber Available"—A hearing aid manufacturer uses Roth Super-Soft in grommets half the diameter of your cigarette—to absorb barely perceptible vibrations. A maker of flexible steel conveyor belts says it provides the tough, watertight, airtight seal he needs. Between these extremes we know there must be a galaxy of other uses. Perhaps you have thought of some already. Roth Super-Soft is a non-porous neoprene base rubber. It is actually softer than some sponge rubber . . . can be molded and die cut . . . bonded by cementing or vulcanization. Consider the possibilities —then write for our booklet that illustrates some uses and gives full information on properties and specifications.

ROTH
RUBBER COMPANY
DIVISION OF VAPOR HEATING CORPORATION
For custom molded products of natural and synthetic rubbers, silicones and silicone sponge
1860 South 54th Avenue, Chicago 50, Illinois

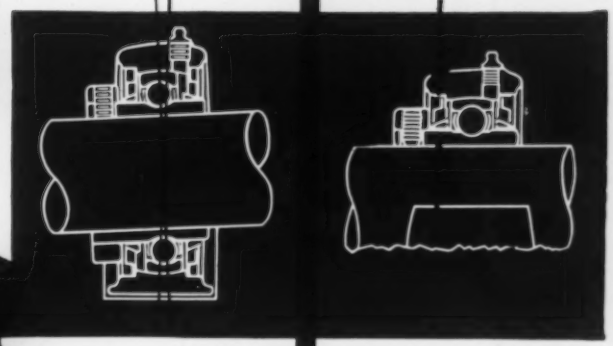
Circle 467 on Page 19

Self-aligning

SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

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LINK BELT

THE SYMBOL OF QUALITY LB LINK BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Circle 468 on Page 19

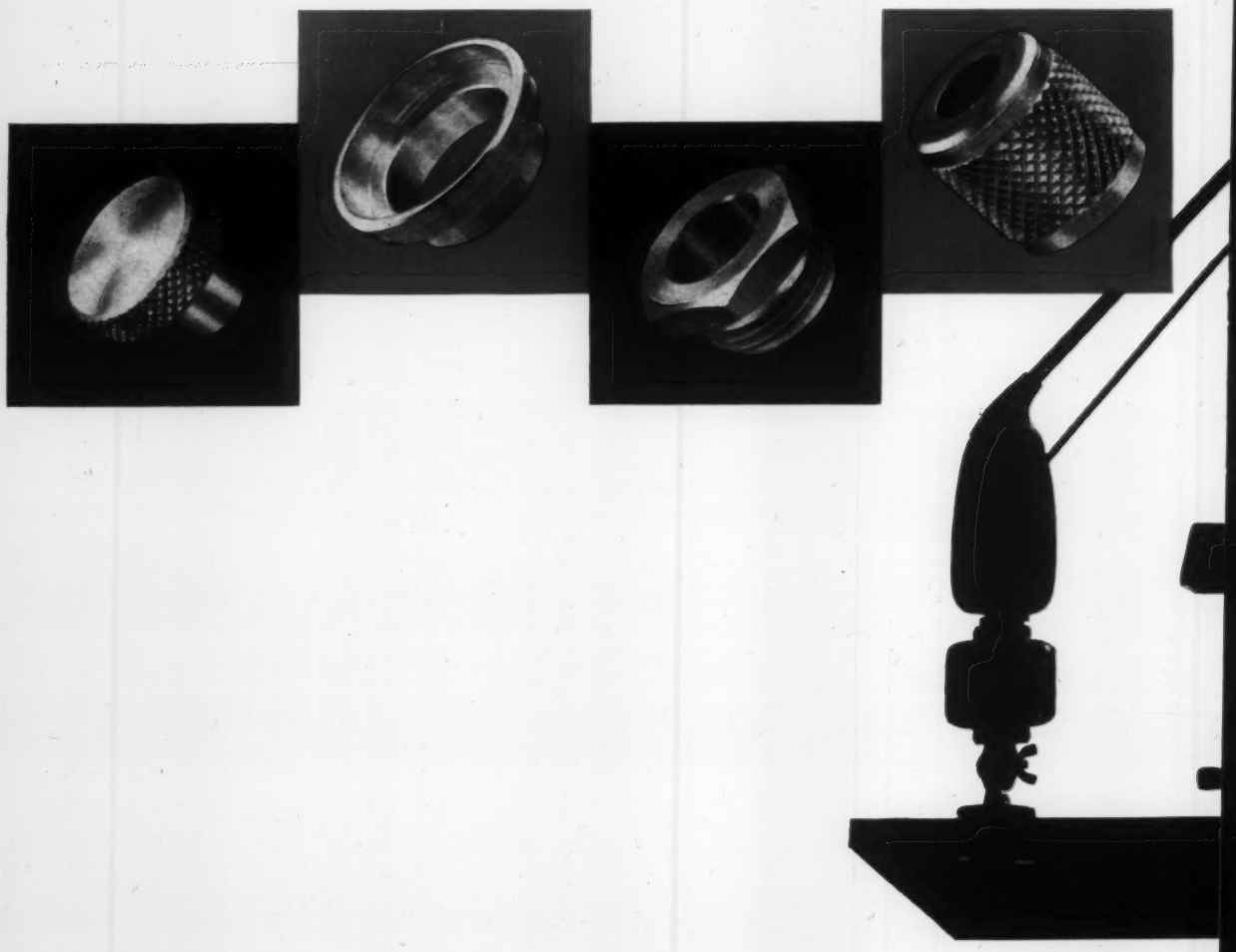
WHAT THE DESIGNER CONCEIVES . . . ALUMINUM ACHIEVES

ALUMINUM'S PRESENT WIDE USE and its increasing importance in all types of fabricating are helping create advanced concepts throughout the fields of metalworking and design.

For screw machine production in particular, aluminum machining has pointed the way to new, better and faster methods of parts production for all ferrous and non-ferrous metals. For example—thanks to aluminum—speeds of equipment are common today which a few years ago would have appeared almost unbelievable.

What are the advantages of screw machine production? To help designers make full use of up-to-date developments, the following checklist presents 12 advantages of modern screw machine production:

1. Starting material is a wrought product which gives high properties in the finished part.
2. Very fine threads possible—as well as accurate threading.
3. Excellent finishing possibilities—anodizing, etching, buffing, etc. As-machined finish gives very fine surface.
4. Closer tolerances and more intricate parts possible than with other methods. Mating parts match better.
5. Excellent concentricity is guaranteed.
6. Fewer rejects for porosity when compared to a cast part.
7. Lower costs for production tooling, dies, set-up; faster delivery of finished parts possible due to fast availability of tooling, speed of set-up.
8. Modification of parts in production easier and less costly.
9. Wide range of equipment and facilities available throughout the country.
10. Fewer secondary operations necessary; possible to avoid secondary finishing by using the as-machined surface.



11. Lower costs for actual production due to high rates of production with available new equipment.

12. Lower costs for finished parts due to competitive pricing among large number of suppliers.

ALUMINUM IN SCREW MACHINE PRODUCTION offers designers more useful properties than any other metal. Check this list of 12 aluminum advantages:

1. Light weight—moving parts present less resistance to applied force, wear less; chips float out of recesses better for cleaning finished parts. Easier handling of raw material in plant, lower freight costs on finished parts.
2. Non-magnetic.
3. Corrosion resistant—can often eliminate finishing.
4. Non-sparking.
5. Lower raw material cost per part.
6. Greater conductivity—helps dissipate machining heat.
7. Some alloys less susceptible to radiation absorption.
8. More alloys available than some other metals, allowing a particular alloy to be related to a particular part.
9. Less price fluctuation on raw materials.
10. Stock readily available. Size range broad and well stocked at distributors throughout the country.
11. New procedures in producing aluminum screw machine stock now give greater tool life and higher production. New processes such as Electrofilming and Kanigen Coating also have overcome old problems such as galling and binding.
12. Technical literature for designing purposes readily available.

For further information and expert assistance, call the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *Executive Office*, Kaiser Bldg., Oakland 12, California; *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois.

See "MAVERICK", Sunday Evenings, ABC-TV Network. Consult your local TV listing.

For The Competitve Edge, Go Aluminum

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

VALVAIR'S universal pilot operates any SPEED KING valve!

Find us fast in the 'Yellow Pages'

Compare ... and you'll buy

Valvair

Immediate delivery from local stock

Valvair's one *universal* pilot—completely interchangeable on all Speed King valves—has only two moving parts. It's built to handle your toughest jobs.

Why complicate production, maintenance and parts inventory on the machines you build or operate, by using control valves that require an assortment of pilots?

For peak performance . . . unmatched reliability . . . minimum parts inventory . . . specify Valvair Speed Kings, the valves with *universal* pilots! Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio.

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OFF THE SHELF—

NO REBORING—

NO KEYSEATING—

NO WAITING!

TAPER-LOCK SPROCKETS
SINGLE AND DOUBLE STRAND!

NOW Taper-Lock *Double* Strand Sprockets are available—from stock—ready for the shaft without re-machining!

They offer all the advantages of Taper-Lock mounting. Easy on! Easy off! Precision machined at the factory, they come to you with accurate, concentric bores —insuring full contact between hub and shaft. Taper-Lock grips with the firmness of a shrunk-on fit!

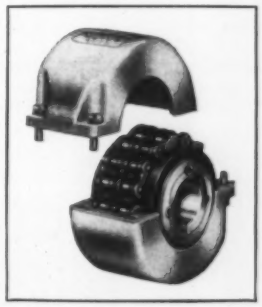
There is no flange, no collar, no protruding part. Flush design means *safety*... If the sprocket becomes worn, you replace only the tooth part. The bushing is used again and again. And Taper-Lock bushings are interchangeable in Dodge Taper-Lock Sheaves, Couplings and Conveyor Pulleys!

Taper-Lock Sprockets and Dodge Roller Chain (made to ASA standards) are stocked by Dodge distributors. Single Strand sizes range from No. 40 to No. 160, up to 112 teeth; Double Strand from No. 40-2 to 80-2, up to 102 teeth. Write for Bulletin A-644 containing selection, installation and maintenance data.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

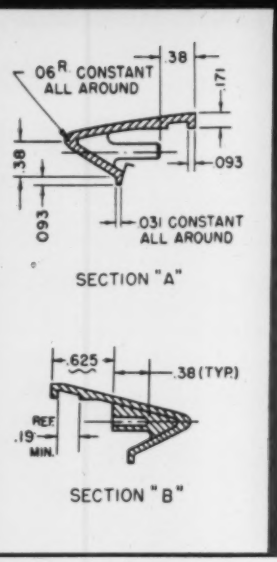


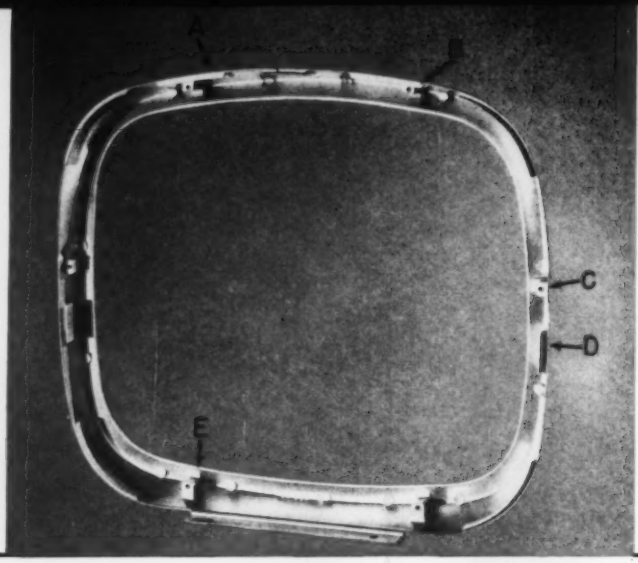
TAPER-LOCK CHAIN COUPLING

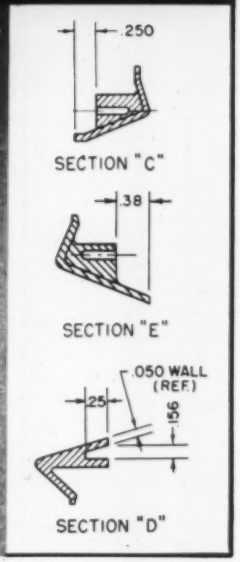
Accommodates common minor shaft misalignments. Provides strong, compact coupling. Available with covers, for appearance, safety, dirt protection and lubrication — which increases coupling life.

FOR *Light Weight with Strength*

ZINC DIE CASTINGS ARE BEST







RCA "HIS MASTER'S VOICE"

RCA Victor proves that the lightest metals do not always produce the lightest weight parts. This RCA Victor Portable Television Receiver is built with a ZINC Die Cast bezel and screen mask that weighs less than one pound, yet provides the strength and rigidity necessary for a structural part of the entire housing.

The sharply edged brow, thin wall sections, streamlined shape, compound curves and built-in conveniences for easy assembly are possible only by the die casting process. Die cast of ZINC, this bezel meets every requirement for the modern styling of the RCA Victor Flight-Line Series of receivers.

HORSE HEAD SPECIAL ZINC AND ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street · New York 38, N. Y.

HORSE HEAD PRODUCTS

MACHINE DESIGN
May 15, 1958

For Balanced Perspective

EVER hear of an inhuman engineer? Besides the boss, that is? The rise of the so-called human engineer does raise a question about the rest of us.

Design engineers create products that serve human needs. But the engineer's education emphasizes scientific principles (things) to the virtual exclusion of human factors (people).

Thus, certain areas of design activity are going, largely by default, to specialists who bring to the art skills not ordinarily possessed by engineers. The industrial designer is taking over more of the artistic and aesthetic aspects. The human-factors specialist is applying psychological and physiological principles to the design of machines and their controls for optimum compatibility between man and machine.

However, specialists tend to be carried away by their pet ideas, and to transmit their enthusiasm to others. Design engineers therefore need to assert themselves to preserve the integrity of their designs.

The best defense is to be well informed. Artistic, aesthetic, psychological, and physiological principles should be added to the engineer's stock of scientific and engineering principles. Then he can, at best, integrate these factors into his design. At worst, he can hold his own against the extravagances of specialists.

"Human Factors Engineering," the current series of articles by Vandenberg and Goldsmith, gives the design engineer working familiarity with a highly important, often neglected, subject on which the specialists are moving in. With the balanced perspective of well-informed design engineers to act as a flywheel, these specialists can be a tremendous help in developing effective designs.

Colin Carmichael

EDITOR

How and when to specify

TOLERANCES OF FORM

By **FRED L. SPALDING,** Assistant Professor
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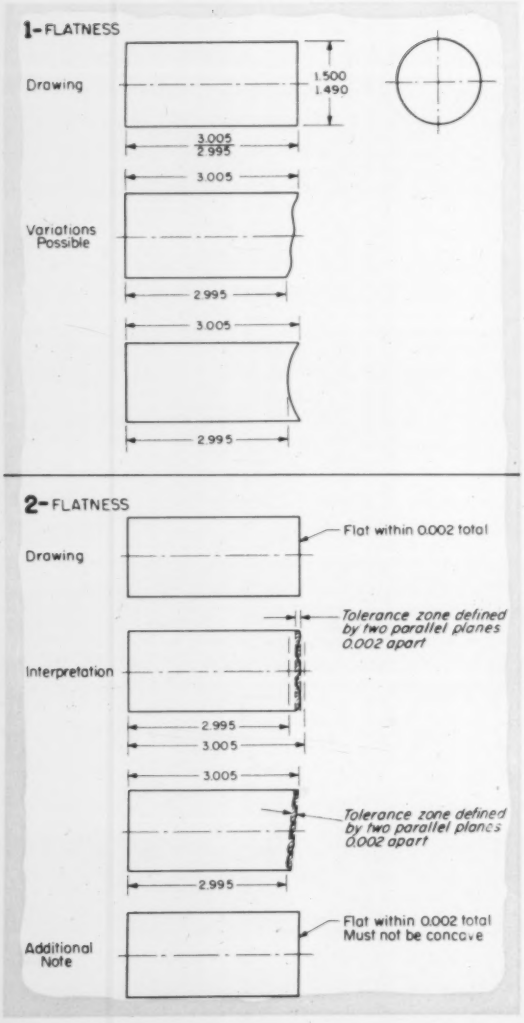


HOW to specify the limits of surface form and location on parts drawings has long been a vexing problem. Such factors as flatness, concentricity, and alignment, have been difficult to indicate on drawings—even when they were realistically anticipated in design. The problem existed because practices and terminology were neither complete nor uniform. A concerted attack on this problem has now led to the standardization of terms and methodology for specifying geometric requirements. This article interprets and summarizes the recommendations of the new ASA standard.

Permissible variations of a part from the perfect form implied by drawings are defined by geometric tolerances, or tolerances of form. Dimensional tolerances indicate size limits, but do not specify how shape or form may vary within those limits. The geometric tolerance specifies a tolerance zone, normally less than the dimensional tolerance, within which a surface, an axis, or a median plane of a feature is to lie.

Geometric tolerances should be specified for all requirements critical to the functioning and interchangeability of the part, even though it is evident that established techniques and equipment can be relied upon to achieve the required standard of accuracy. The tolerance is generally specified for the entire surface, axis, or median plane, regardless of its area or length. However, it may be desirable to specify it in terms of linear deviation per unit of area or length, such as "straight within 0.020 in. per foot" or "square within 0.002 in. per inch run."

Datum Surfaces: Tolerances are usually given with reference to a datum surface. To be useful, the datum on the actual part must be available and accessible so that measurements can be made from it. It must be more accurate than variations allowed in any measurements made from it, and close tolerances on its geometric form may be necessary.

The dimensioning section of the American Drafting Standards Manual, approved last fall, introduces some practices which may be new to many drafting rooms. One of these is geometric tolerancing for control of variations in form (ASA Y14.5-1957).

For industries where close tolerances are required, tolerances of form provide a new language for specifying required accuracy—more completely and more uniformly. This article, prepared by a member of Review Group Y14.5, presents these new tolerances and tells when, why, and how to use them.

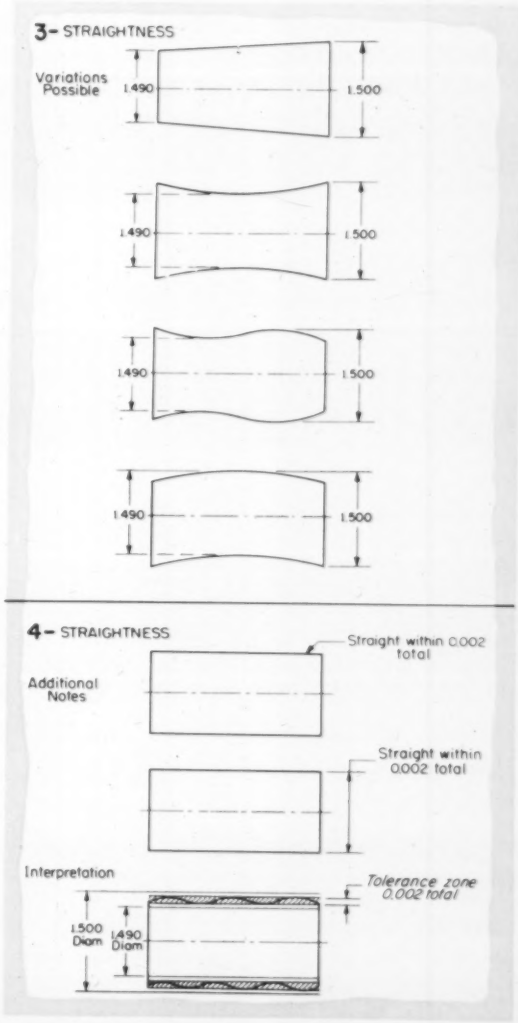
The illustrations in this article do not indicate datum-surface tolerances. The figures are simplified to make the meanings clear and are not typical of actual practical drawings. Notes in roman letters are as they would appear on the drawings. Notes in italic letters are explanatory only and would not appear on actual drawings. No attempt has been made to show all the variations of form that may occur when only dimensional limits are given—only a few representative shapes are illustrated.

Limits of Form: Maximum limit defines a maximum-permissible profile for the part and minimum limit defines a minimum profile. Variations may be of any degree, as long as no portions of the part are outside the limits, and provided there is no conflict with supplementary specifications. Without geometric specifications, the tolerances on dimensions, however expressed, are the only control of form.

Flatness

Numerous errors of flatness could be accepted by assuming that dimensional limits define the form, since a surface may vary by any amount as long as the entire surface lies within the limits, Fig. 1. Flatness can be controlled to a greater extent by a flatness tolerance. This tolerance is the distance between two parallel planes between which all points on the surface must lie, and is specified by a note as in Fig. 2.

The notation shown means that all points on the surface must lie between two planes, 0.002-in. apart, which establish the tolerance zone, and which lie within the limits of the dimensions. The flatness tolerance expressed is independent of the size tolerance specified by the limit dimensions. Thus, the tolerance zone may be anywhere within the limit dimensions and still satisfy the tolerance



specification. To further define the surface, words such as "must not be concave" or "must not be convex" may be added to the tolerance specification.

Straightness

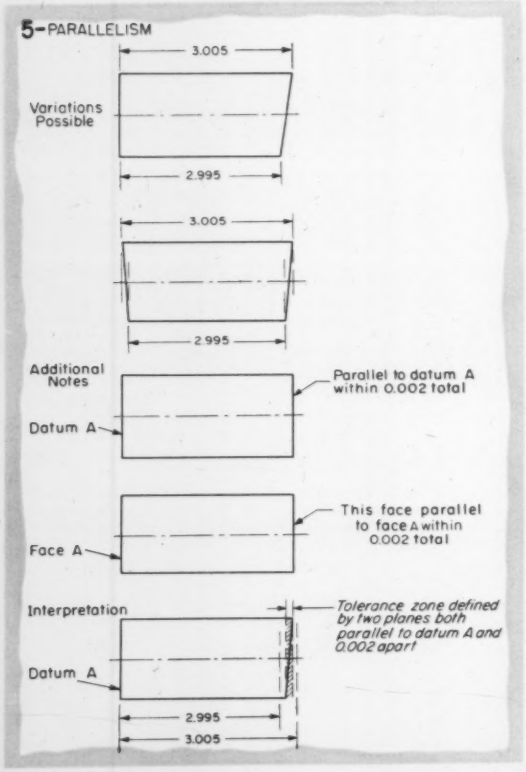
In a simple cylindrical part, straightness may vary in several ways, Fig. 3. If no tolerance on straightness is specified, the part may be of any shape as long as it is within the zone between the maximum and minimum diameters. These cylindrical forms need not be concentric as long as the smaller is contained entirely within the larger.

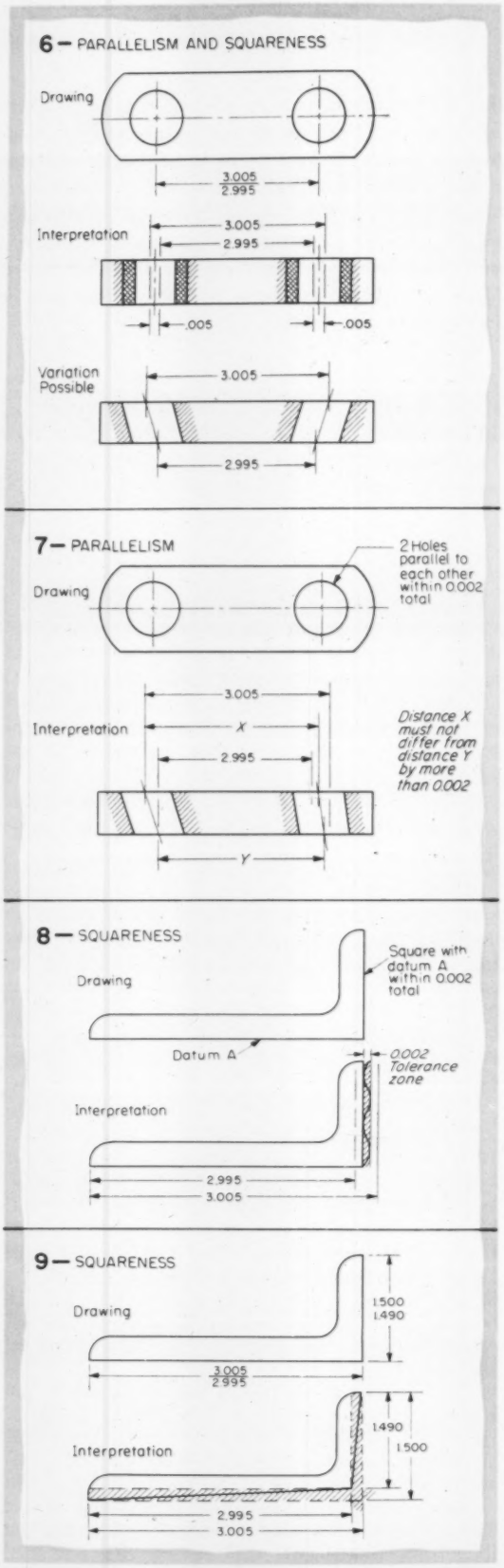
To further limit the permissible deviation of the elements of the cylindrical surface from a straight line, a straightness tolerance must be specified. The tolerance specification merely reduces the size of the tolerance zone within which all points on the surface must lie, and is specified by note, Fig. 4.

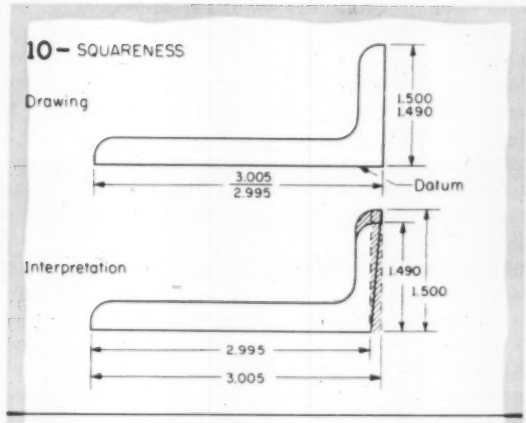
For a square or rectangular bar, straightness may be applied to any face of the bar. The straightness tolerance is always in the direction of the longer dimension of any face. If the shorter dimension is to be controlled, specify flatness.

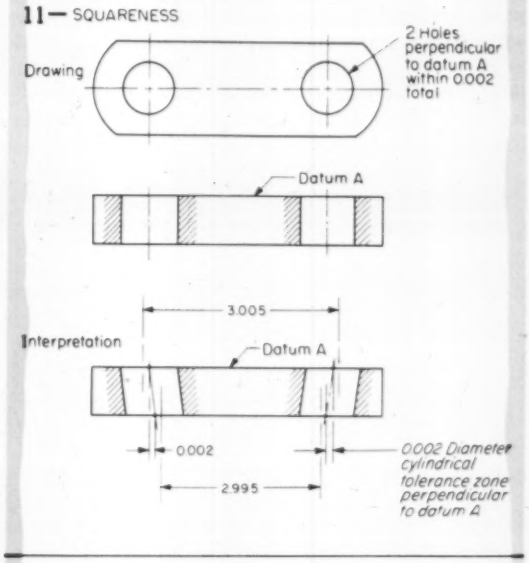
Twist

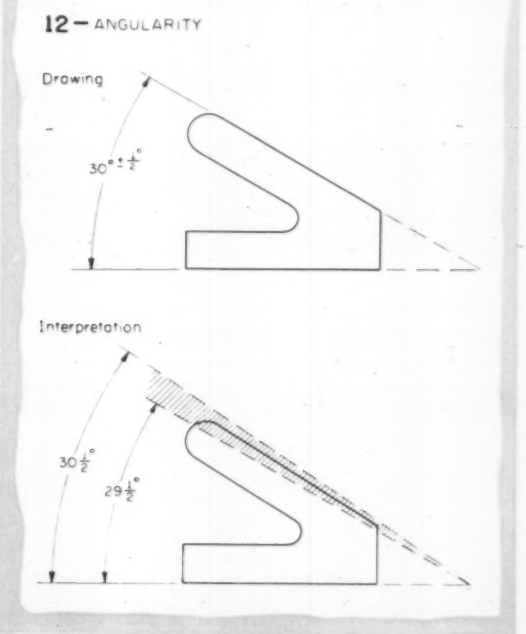
Torsional distortion of a rectangular bar or plate results in a deviation by the faces from a plane











surface. Most cases of twist will be controlled by a specification of flatness, straightness, or alignment. However, in some cases it is desirable to specify permissible variations of only the ends or bearing surfaces, without specification of the flatness or straightness of the joining surfaces, as in tie rods or links.

On commercial products like rolled bars, structural shapes, and extruded sections, the tolerance on twist is usually specified in terms of degrees of twist per foot with a maximum figure which is not to be exceeded regardless of length.

Parallelism

If no tolerance on parallelism of surfaces is stated, it is assumed that features shown parallel on the drawing will be parallel within the limit dimensions specified. A tolerance governing parallelism to a datum merely limits the width of the tolerance zone within which the relevant surface must lie, Fig. 5.

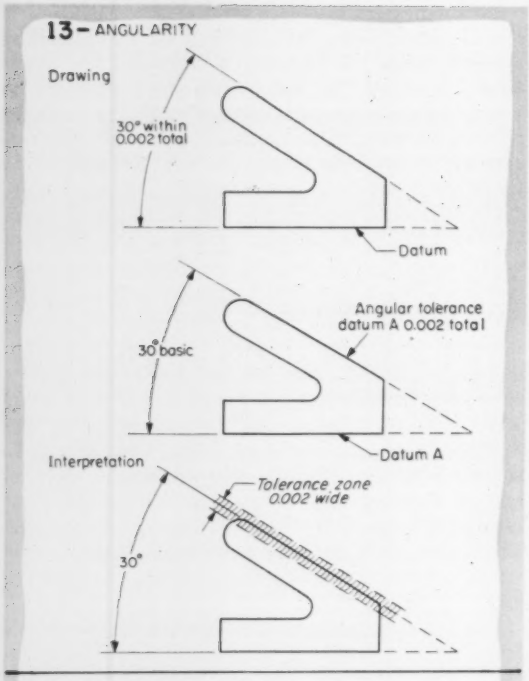
To limit the amount of deviation in the parallelism of two surfaces, a tolerance must be specified. It is important that the word "total" be included in the note. Otherwise, it might be interpreted as a bilateral tolerance—a tolerance zone 0.004-in. wide. Without additional specification regarding the datum, it may be out of square with the length of the part.

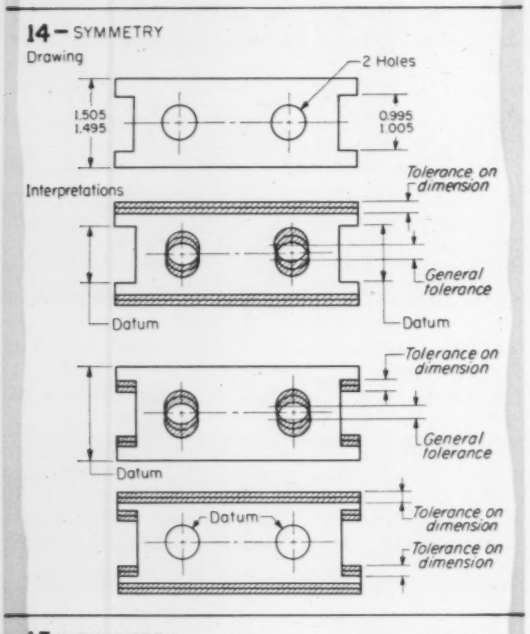
Parallelism specifications may also apply to features other than surfaces. For example, a drawing may show two holes in a part as in Fig. 6. The normal interpretation of this limit dimension is that the part is acceptable if the mean center lines of the two holes lie within two tolerance zones of 0.010-in. total width. This means also that the holes may be at an angle to the end surfaces of the part and/or to each other.

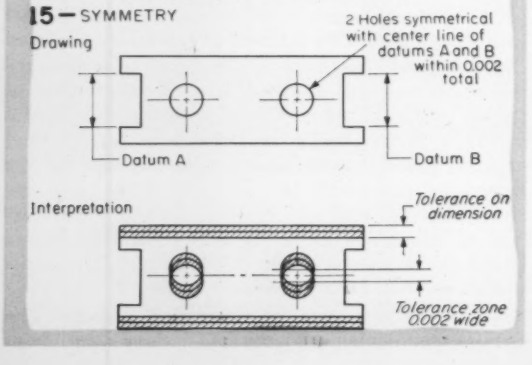
However, if a parallelism tolerance between the two holes is specified, the angularity between the holes is limited, but the angularity between the holes and the end surfaces of the part is still controlled by the center distance limits, Fig. 7.

Squareness

To limit the amount of deviation from perfect squareness of two surfaces to a greater extent than that imposed by limit dimensions, a squareness tolerance may be specified, Fig. 8. Variations of the surface are thus contained within a zone 0.002-in. wide, perpendicular to the datum surface, and located within the tolerance zone defined by the limit dimensions. In this example, since only one dimension has been given, the undimensioned surface of the angle must be considered the datum. However, if both surfaces of the angle are dimensioned and no datum is specified, Fig. 9, the outer ends of the legs may be considered datums. The two perpendicular surfaces may then vary from



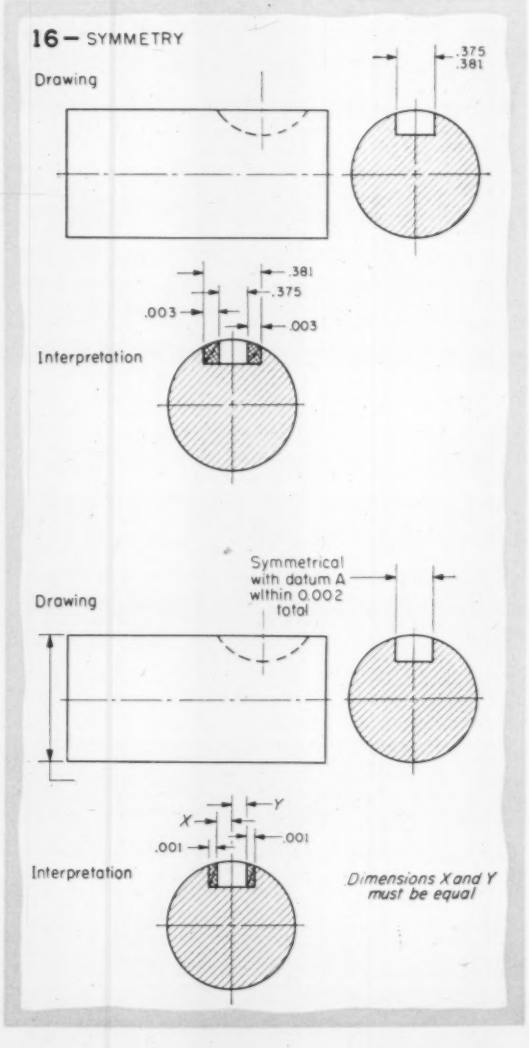




their true positions to the extent of the limit dimensions. Specifying one of the square surfaces as a datum, as in Fig. 10, limits all of the deviation from perfect squareness to the other surface, and any variation in length of the nondatum leg is limited to the outer end.

Squareness specifications may also apply to features other than surfaces. For example, two holes may be shown in a part as in Fig. 6. Without specification of geometric tolerance, the part is acceptable if the mean center lines of the two holes lie within two tolerance zones of 0.010-in. total width.

To limit the out-of-perpendicularity of the holes with either surface of the part, a tolerance must be specified, Fig. 11, that will limit out-of-squareness with the datum surface to the amount of the tolerance. Center lines of the holes must then lie within cylindrical tolerance zones 0.002-in. in diameter and perpendicular to the datum. The tolerance cylinders may lie anywhere within the larger tolerance zones established by the limit dimensions. This specification also controls parallelism of the two holes to within a total tolerance of



twice the individual perpendicularity tolerances.

Angularity

In the common method of tolerancing angular surfaces by specifying a tolerance on the angle, the tolerance zone varies from zero and becomes wider as the distance from the apex of the angle increases, Fig. 12. This way of stating requirements may allow parts to vary outside desired limits and manufacturing and inspection operations to meet the stated requirements may be difficult, if not impossible.

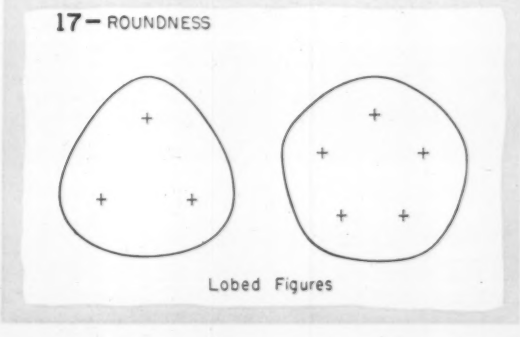
Linear limits, with the angular tolerance specified as a linear distance, are better suited for angular features and allow the angle to vary from the basic value, Fig. 13. Notations mean that the surface must lie within a tolerance zone 0.002-in. wide and bounded by two planes, both at the specified angle with the datum surface.

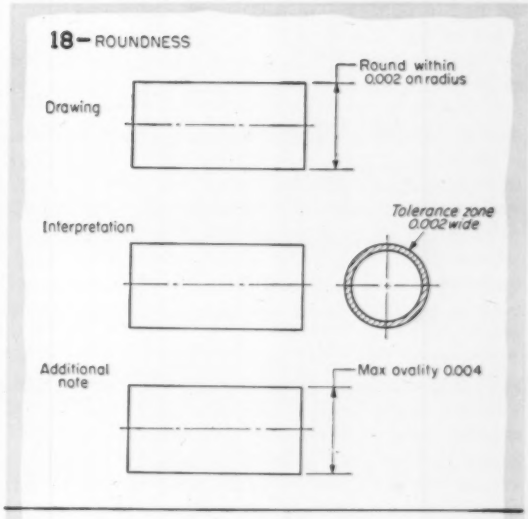
Symmetry

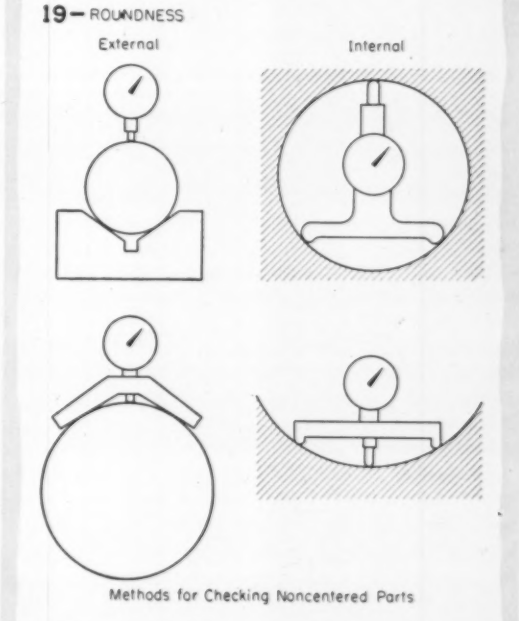
If no tolerance on symmetry is specified, features may vary from their true position on opposite sides of the center plane, or from their true position on the center plane. The direction of the variation is perpendicular to the center plane, and may be the amount of their individually stated tolerances, or the amount of the general tolerance on the drawing. When a datum surface is not specified, various tolerance diagrams may be obtained, depending on which surfaces or features are considered as establishing datum, Fig. 14.

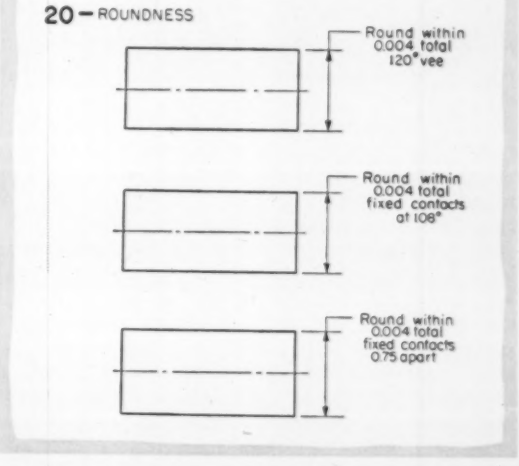
Tolerances for symmetry limit the amount of this variation, Fig. 15. The notation means that the two holes may be 0.001-in. either side of the mean center plane of widths *A* and *B*, regardless of the actual widths but within the limit dimensions of *A* and *B*. Use of the word "total" means that the total tolerance is equally divided on either side of the true position of the center plane. Thus, in the example shown, the 0.002-in. tolerance zone is located 0.001 in. on each side of the center plane.

The word "total" must be included in the symmetry tolerance note or the note may be interpreted to mean that the holes are to be symmetri-








20 – ROUNDNESS
Round within 0.004 total 120° vee
Round within 0.004 total fixed contacts at 108°
Round within 0.004 total fixed contacts 0.75 apart

cal within 0.002-in. in relation to the mean center plane of the two slots. That is, the centers of the holes could vary 0.002-in. either side of the mean axial plane for a total variation of 0.004-in. In this interpretation, the 0.002 in. would be a permissible deviation from the true position, and not a tolerance. A note without the word "total," unless thoroughly standardized, may lead to misinterpretation.

In many cases, it may be simpler to specify tolerances for symmetry as true positions. Symmetry tolerances, however, permit different values for tolerances perpendicular and parallel to the center plane.

Where a size tolerance is given on a symmetrical feature, such as a keyseat, the symmetrical location of the feature must be within the size tolerance specified. If greater symmetrical accuracy is required, regardless of feature size, a symmetry tolerance may be specified as shown in Fig. 16. With this notation, the slot must be centered on the circular part within the total amount of the tolerance, regardless of the actual size of the slot.

Roundness

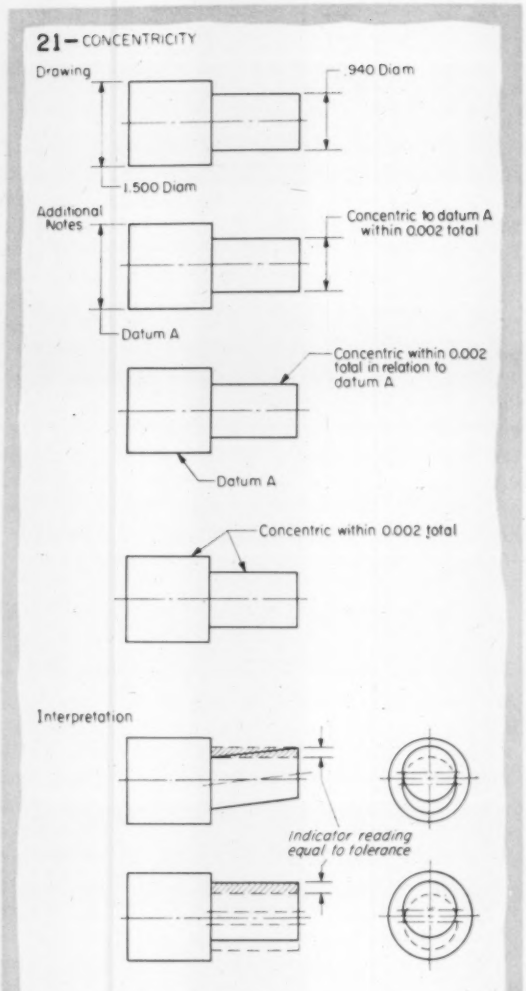
A simple cylindrical part or feature is usually considered round within the limit dimensions on the diameter. It is rarely necessary to specify tolerances for roundness because errors present in cylindrical surfaces are usually well within the limits of size and within the limits required for assembly and functioning. These are cases in which the permissible errors are, for functional reasons, so small that the necessary accuracy cannot be guaranteed automatically by normal machining processes. In these cases, it is necessary to specify tolerances for roundness.

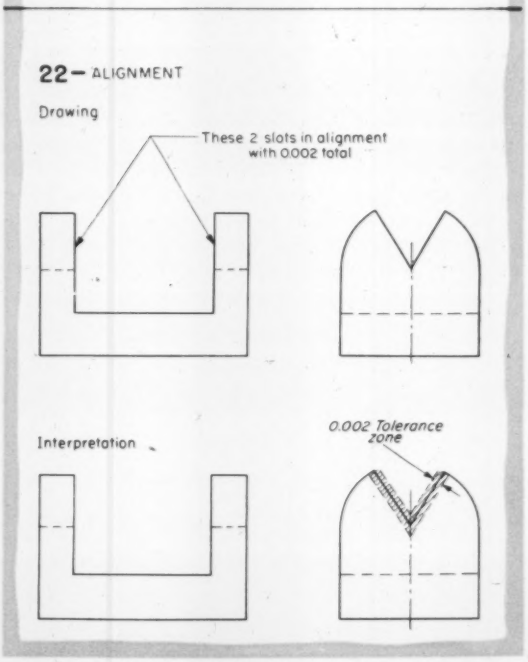
Diametral measurements cannot, by themselves, prove that a feature is round. "Lobed" figures suffer from errors of roundness even though their diametral measurements—the distance between any two parallel tangential planes—are constant, Fig. 17.

If a part can be checked on centers, errors of roundness can be toleranced by establishing an annular tolerance zone within which the finished surface must lie, Fig. 18. Such a tolerance specifies that the surface must lie between two concentric cylinders separated by the width of the tolerance zone.

These tolerance notes actually control ovality rather than roundness. Ovality may be defined as the maximum difference in diametral measurements on any cross section of a circular part. It is better to state this tolerance as ovality.

If rotation between centers is not practicable, such a tolerance is exceedingly difficult to check because of the infinite variety of errors of form that may occur and the difficulty of establishing a perfect cylinder with which to compare the finished surface. When centers are not available, it is advisable to add to the tolerance a note specifying how it is to be checked, usually by a vee-block and indicator or an indicator which meas-





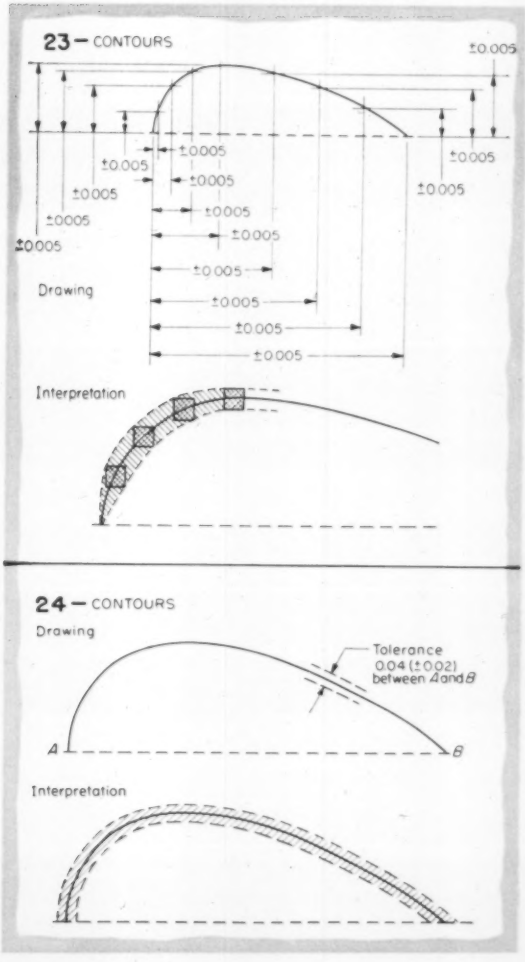
ures across three points, Fig. 19.

Readings obtained by these methods cannot be related to a tolerance specified by the annular-ring method without an involved analysis of each individual part being checked. Therefore, the tolerance should be expressed as the total indicator movement permissible when using a particular vee-block angle or arrangement of fixed contacts, Fig. 20.

Concentricity

The tolerance governing concentricity of axes is the diameter of the tolerance zone within which the axes of the concentric features must lie. This may be checked by an indicator and is thus expressed as the permissible variation in the run-out of the surfaces.

It is generally assumed that all circular surfaces not covered by a specific tolerance are concentric within any general tolerance on the drawing. If closer concentricity must be maintained, a concentricity tolerance must be specified, Fig. 21, in terms of the maximum total indicator reading.



Alignment

The tolerance specifies the width of a zone located within the limits of the dimensions, and within which all points of the aligned surfaces must lie, Fig. 22. No part of the surfaces of the aligned features may deviate outside of a tolerance zone symmetrically disposed about the true shape and equal in width to the amount of the tolerance.

Ordinarily, alignment tolerancing would probably be covered by tolerances on flatness, parallelism, concentricity, or symmetry. However, there are some cases where a specification of alignment tolerance is necessary.

Contours

Irregularly shaped surfaces are conventionally dimensioned by coordinate distances from a datum plane and a line in the plane, represented on the drawing by a line and a point. The dimensions run perpendicular to the datum line, and parallel or perpendicular to the datum plane, Fig. 23.

Where each of these co-ordinate dimensions is directly toleranced, the tolerance zone of each located point is a square or a rectangle. The actual material tolerance normal to the surface may vary with the shape of the profile, being greatest as the contour approaches 45 degrees, least when the contour is more nearly vertical or horizontal, and zero at the datum point on the contour.

The zone method of tolerancing contours provides a uniform tolerance zone normal to the profile at all points. The contour is dimensioned by use of basic, untoleranced dimensions, and a tolerance zone for the finished profile is shown at a conspicuous place.

The tolerance zone is shown by one or two phantom lines with dimensions to indicate location of the tolerance zone, Fig. 24. For clarity, the distance between contour and phantom lines on the drawing should be made considerably greater than its actual scale value. The region controlled by the tolerance zone must be clearly specified, either by indication of the terminals of the zone, or by a notation that the tolerance zone extends around the entire profile.

Basic dimensions locating the true profile must be given with some indication that the general drawing tolerances do not apply. Where a general tolerance note is not used, and all dimensions other than basic and reference dimensions (those specifically labeled) are individually toleranced, any specific indication that these dimensions are basic may be omitted. In such cases a general note may be used to indicate that all untoleranced and not otherwise specified dimensions are basic.

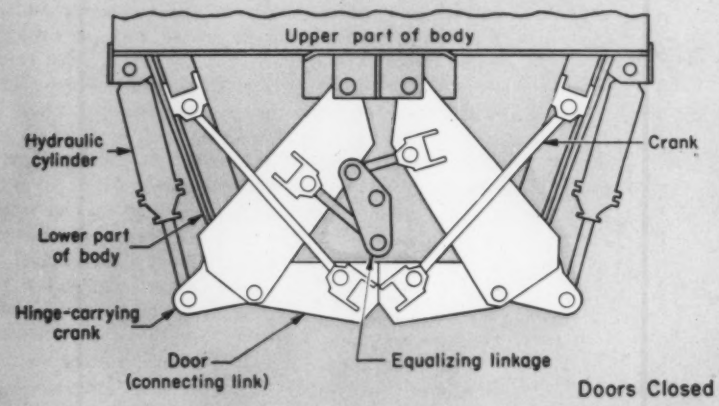
Additional Reading

This article is an interpretation of Section 5 of the American Drafting Standards Manual, Dimensioning and Notes, ASA Y14.5-1957. Section 5 may be purchased from The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y. The cost is $2.00.

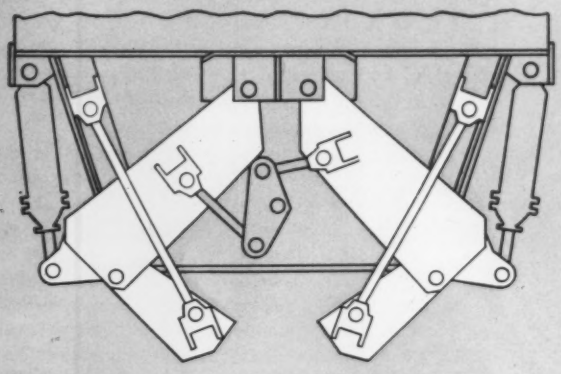
scanning the field for *ideas*

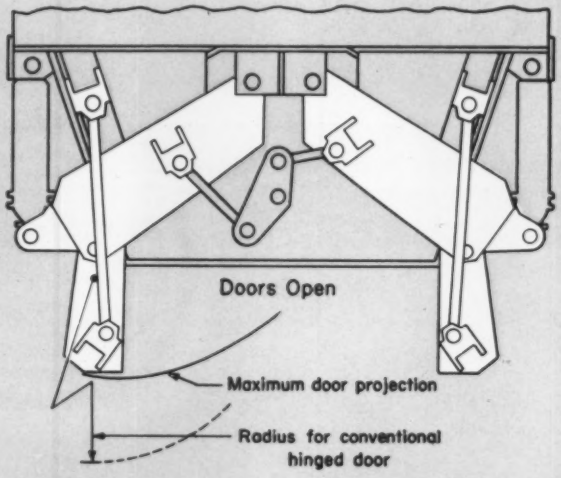
Moving hinge pivot for power-operated door or panel members compresses the space required for swinging clearance and reduces length of stroke of actuating device. The hinge design is an adaptation of the four-bar linkage in which the door member is the connecting link and is operated by movement of one of the cranks. This crank carries at its free end a pivot for the door link and a clevis for attachment to the end of the piston rod of a hydraulic cylinder. The other crank restrains the nonhinged side of the door.

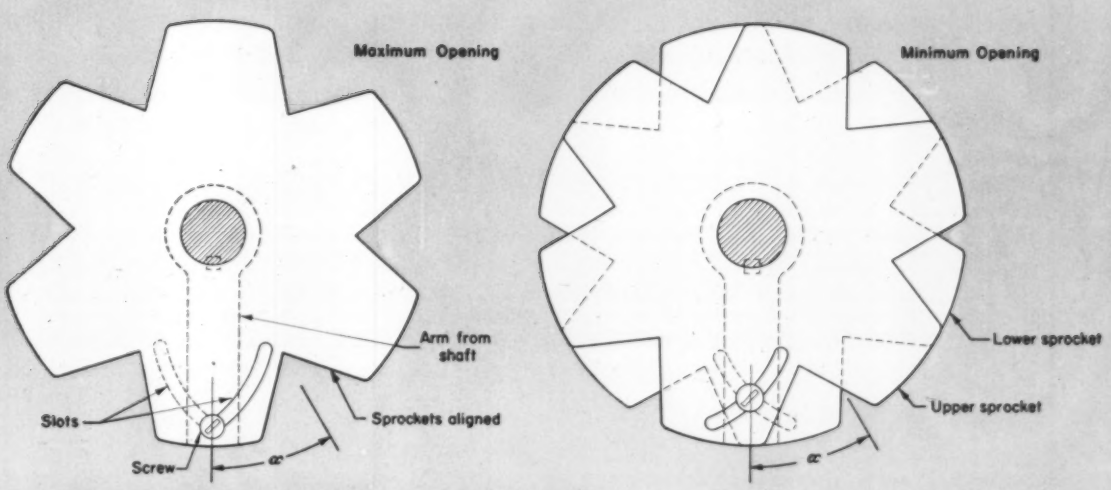
When the door is closed, the cranks are crossed and the cylinder piston rod is extended. As the piston retracts, the free end of the hinge-carrying crank moves toward the base link, causing the door to open as its hinge moves and its opposite side is held at a fixed distance by the second crank. The design was developed by Construction Machinery Div., Allis-Chalmers, for a dump-bottom motor wagon.



Doors Closed

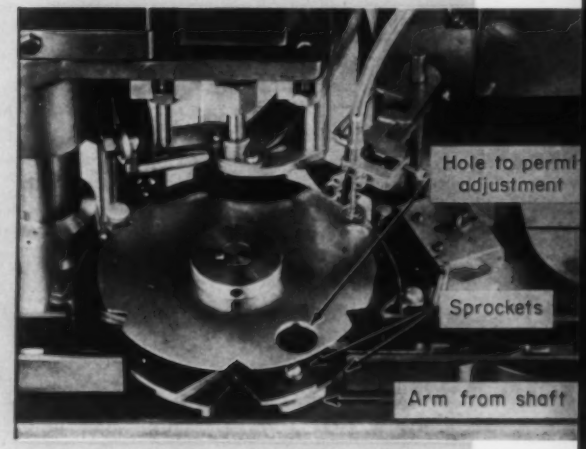




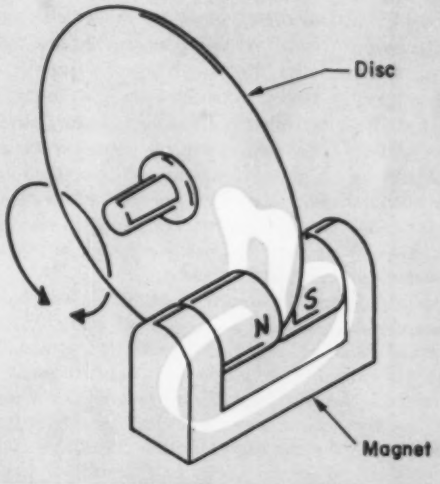


Adjustable indexing sprocket in an automatic feed device accommodates various sizes of parts without altering radial position of the centerline of the part openings on the sprocket. The sprocket consists of two similar circular plates, each with a number of V-notches in the periphery. The plates are mounted on a common shaft; rotation of one plate in relation to the other either enlarges or reduces the effective size of the notches.

To maintain the radial location of the notches, an arm is mounted on the shaft and a sliding nut is fitted into a slot at its end. A screw passes through two crossed slots, one located on a tooth of each sprocket, and engages the nut to cause rotation of the shaft and arm to drive the sprocket plates. To adjust the size of the openings, the screw is loosened and moved toward or away from the shaft, causing the slot in each sprocket to move an equal amount and keeping the sprocket teeth, and thus the notches, in line. The sprocket was designed by Chase Equipment Corp. to feed bottles to a filling and capping machine.



Damping of induced oscillations or flutter motions in rotating members is provided by an application of eddy-current phenomena. Developed by Lyndon Aircraft Inc., the Eddy-Trol damper employs a metal disc whose edge is rotated between two fixed magnets by the assembly for which it provides damping. As the disc rotates in the magnetic field, eddy currents generated in the disc develop a second magnetic field. The resultant force of these two fields opposes rotation of the disc. Since the damping rate is proportional to the input speed, sudden changes in this speed are opposed, with the damping force tending to preserve the lowest input speed.



Human-Factors Engineering—3

IN THE man-machine system, hearing ranks second only to vision as an information gathering sense. But, as a human-factors problem, hearing—or, more specifically, noise—often outranks vision, particularly since high-level noise can damage the ears, or cause accidents through interference with voice communication or warning signals.

When hearing effectiveness becomes a design problem, the first concern of the human-factors engineer is to make use of the ear's known characteristics to recommend tolerable noise levels, preferred pitch of signals, and best methods for carrying out intelligible verbal communication. Paralleling these efforts in the human-factors area are the familiar techniques for reducing the intensity of the offending noise source or for isolating and shielding it.

Sound and Hearing

Considered as a mechanical phenomenon, hearing depends on the interaction of three elements: 1. A *vibrating body*, such as a tuning fork or a loudspeaker. 2. A *medium* for transmitting such vibrations. 3. The *ear* and its associated elements.

When a body vibrates, air molecules near the body are pushed in the direction of its movement, creating a moving "front" wherein molecules are tightly packed. Because the molecules in this compression front originally occupied some space, a region behind the front contains a less-than-normal number of molecules. Thus, one complete sound-wave cycle constitutes a higher-than-ambient pressure area (compression) and a below-normal pressure area (rarefaction). As the source body continues to vibrate, a series of such compressions and rarefactions follow each other through the air.

This simplified structure illustrates the physical parameters of sound. The degree of compression is the pressure level or intensity of the sound. The linear distance between one compression front and the next is the wavelength. Frequency or number of waves per second can be found by dividing the speed of sound by the wavelength.

The idealized sound wave just described has the form of a sine wave. The ear hears it as a "pure" tone, that is, a simple tone of just one frequency. In reality, most sound waves consist of a number of component tones. If all components are multiples or harmonics of the fundamental frequency in the wave, the sound is called periodic. Sounds with irregular wave patterns are called noise, and "white noise" is a term that refers to a sound that contains all frequencies. These three wave-forms are shown in Fig. 1.

How the Ear Works

A functional diagram of the ear is shown in Fig. 2. Pressure waves traveling through the air enter the

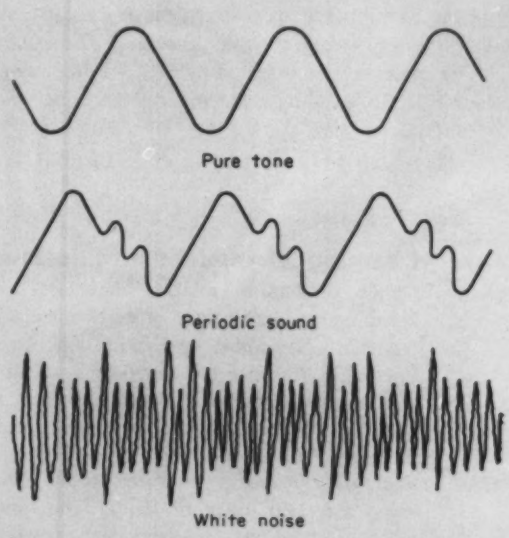


Fig. 1—A pure tone, which contains one fundamental frequency, has the form of a sine wave. Adding harmonics to the fundamental produces a complex but still periodic wave. White noise, which contains all frequencies, has no regular wave form

Design for Hearing

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ear canal and strike the ear drum, which is a thin, tough membrane. Vibrating in sympathy with the pressure waves, the ear drum transmits its movement to bones in the middle ear. The mechanical advantage gained in the middle-ear bones is about 20 to 1. These magnified motions are next transmitted to the oval window, which is another tough membrane.

The oval window is the entry to the cochlea, which is a spiral canal with about 2½ turns and 3 channels. Each channel is filled with fluid which is displaced by the pressure at the oval window. Tuned to various sound-wave frequencies, minute hair cells in the cochlea are stimulated into response. These hair cells, serving as transducers, then

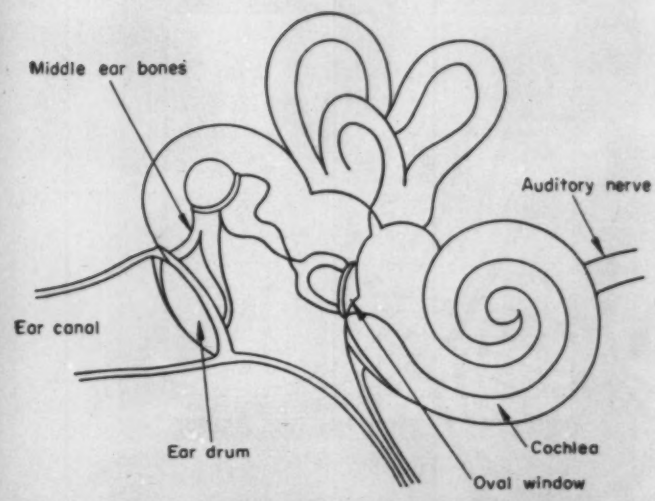
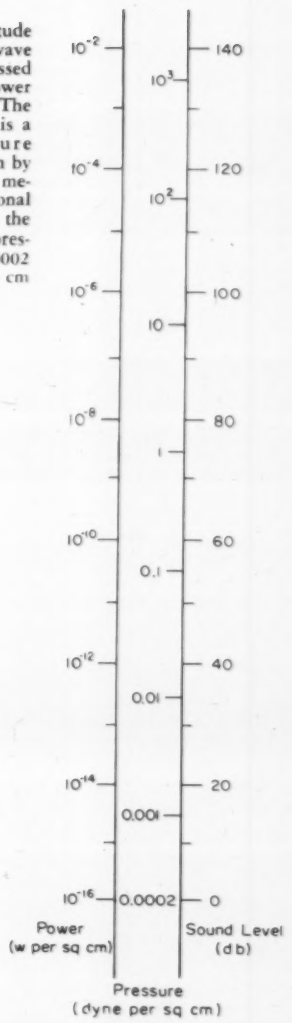


Fig. 2—Principal parts of the ear. Movement of the ear drum, magnified by the middle ear bones, is transferred to the oval window which, in turn, displaces fluid in the cochlea. Hair-like nerve endings in the cochlea are stimulated, thereby sending nervous impulses to the brain to give the hearing sensation

Fig. 3—Magnitude of a sound wave may be expressed in terms of power or pressure. The decibel, which is a relative measure commonly given by a sound-level meter, is proportional to the log of the ratio of sound pressure to a 0.0002 dyne per sq cm reference level



send electrical impulses down the auditory nerve to the brain where the signal is interpreted as sound.

Measuring Sound Intensity

Sound pressure level, which is a measure of the loudness of a sound wave, is measured in decibels. Abbreviated db, the decibel reading is 20 times the log of the ratio of the given sound pressure to an arbitrary reference pressure of 0.0002 dynes per sq cm.

Because energy in a sound wave increases as the square of the pressure, direct comparison of decibel readings provided by a sound-level meter can be misleading. For example, assume that the sound level in a business office is measured as 60 db, while the level at a factory punch press is 120 db. To one unfamiliar with interpretation of the decibel unit, these readings may seem to indicate that the factory is twice as noisy as the office.

This is a mistake. The 60-db level, translated into energy terms, corresponds to 10^{-10} energy units. The punch-press noise level represent 10^{-4} energy unit, or 1-million times more energy than produced by the office machines. As a rule of thumb, increasing the intensity of a sound by 3 db approximately doubles the sound energy. Power, pressure, and db levels are related in Fig. 3.

Response of the Ear

The hearing sensation depends primarily on two parameters discussed in foregoing sections: 1. Frequency. 2. Intensity. Frequency determines the sound *pitch,* with low frequencies yielding low tones and high frequencies yielding high tones. Intensity determines the *loudness* of the tone.

The human ear is capable of responding to frequencies up to about 20,000 cps. But, in order to be perceived, some frequencies must be presented at higher intensities than others. The relative sensitivity of the ear to various frequencies is shown in Fig. 4. These are average curves for 20 to 29 year old subjects. Different curves result if the age group is changed. Note that at very low frequencies, only 60-db or louder tones can be heard; on the other hand, in the frequency range between 1000 and 3000 cps, the threshold is near 0 db. To develop 60 db in a 20-cps tone requires a tremendous amount of energy, while at 1000 cps, the ear responds to pressures of less than 10^{-6} gm.

Fig. 4 also shows an upper curve for the threshold of feeling of the ear. These values provide a safe indication of the upper limits of auditory tolerance. Although sounds of up to 140 or 150 db have been experienced without injury by some individuals, this fact is no assurance that everyone can be exposed without injury to such loud noises. Exposure to sounds of lesser magnitudes for any appreciable length of time results in a loss of auditory sensitivity. Fig. 4 shows that at the most sensitive region (between 2000 and 3000 cps), the useful range of intensities is about 120 db, or a ratio 1 to 10^{12}.

The hearing threshold denotes the faintest sound that can be heard 50 per cent of the time and varies greatly in a normal individual. A 1000-cps tone may give a threshold of 0 db at one instant and 5 db the next. Within the "normal" population, the auditory threshold varies by as much as 20 db.

Another threshold of interest is that which measures an observer's ability to detect the frequency difference between two tones. The change in frequency required in order that an observer can detect the change is plotted in Fig. 5.[1] Similarly, Fig. 6

[1]References are tabulated at end of article.

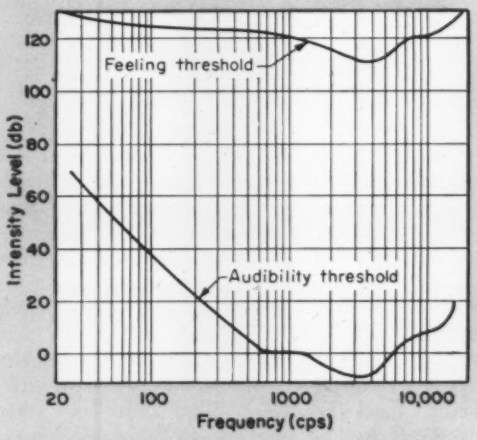


Fig. 4—To be barely audible, a sound must be more intense at some frequencies than at others. The lower curve, which is the threshold of audibility, shows the ear to be most sensitive in the 2000 to 3000 cps range. The upper curve, or threshold of feeling, shows levels where sound begins to cause pain

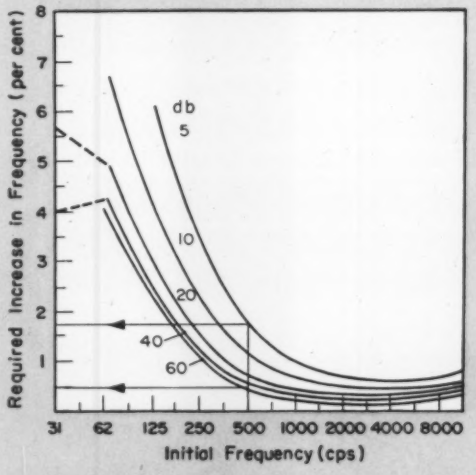


Fig. 5—Ability of the ear to detect differences in the pitches of two tones depends on intensity and frequency. For example, a 5-db tone at 500 cps must have its frequency raised about 1.7 per cent (to approx. 508 cps) before the ear can detect the frequency change. At 60 db, on the other hand, a 500-cps tone can be distinguished from a 502-cps tone

shows the change in intensity required for detection by an observer.[2] Note that for each parameter considered, the change required is a function of the other parameter.

Measuring Complex Sounds

It has been shown in preceding sections how the ear responds to and distinguishes between pure tones. Unfortunately, pure tones are seldom heard, since almost all musical and speech sounds are complex. The pitch of any complex tone depends primarily on its fundamental frequency; overtones simply add distinguishing characteristics to the note.

In practice, several different scales are used in comparing sounds. The first of these is the *sensation level*, which is the intensity of the sound in decibels above its absolute threshold level. The decibels in Fig. 5 and 6 are in these terms.

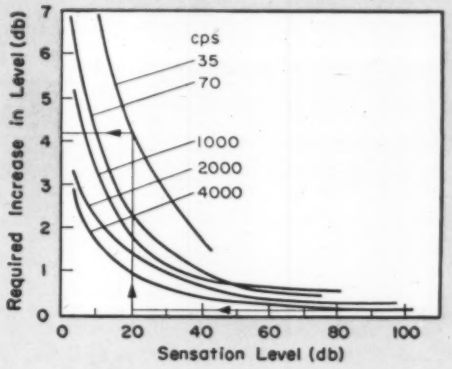


Fig. 6—Increase in intensity required for two tones to be judged as different in loudness depends on initial intensity and frequency. For example, a 35-cps tone presented at 20 db must be raised to 24.3 db before the intensity difference can be detected. However, a 4000-cps tone at 90 db need be increased to only 90.2 db before the intensity difference is noticed

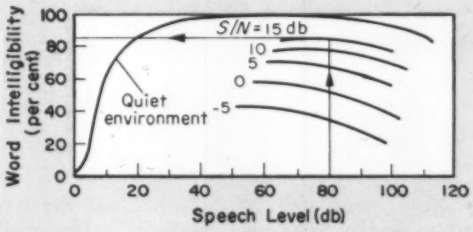


Fig. 7—To be intelligible in a noisy environment, speech sounds must be presented at an adequate signal-to-noise ratio (*S/N*). In absolute quiet, the plot shows speech to be almost 100 per cent intelligible at 40 db. With an *S/N* ratio of 15 db, speech is only 85 per cent intelligible even at 80 db

The *phon* scale is another measure used to deal with equal loudness levels. The reference point on this scale is a 1000 cps tone against which all other tones are measured.

To determine loudness of a given tone in phons, a 1000-cycle tone is adjusted until it sounds equal in loudness to the given tone. The number of decibels generated by the 1000-cycle tone equals the number of phons in the given tone. This matching has been done for a large number of frequency and decibel combinations. Charts have been prepared so that, in order to find the number of phons in an unknown tone, it is only necessary to determine frequency and intensity and refer these values to one of the curves.

The *sone* scale is a scale of subjective loudness. One sone is produced by a 1000-cycle tone of 40-db intensity. A sound which is judged twice as loud as this is a 2-sone sound; one judged three times as loud is a 3-sone sound, and so on.

Speech Intelligibility

Human speech is made up of complex tones that fall within a frequency range from 100 to 8000 cps. In a quiet background, the intelligibility of speech (in terms of the number of words correctly perceived) depends on the intensity of the speech sounds. Fig. 7 shows that as the intensity of speech increases to about 40 db, virtually 100 per cent of the speech sounds can be heard. As intensity increases beyond about 100 db, intelligibility decreases slightly.

Since speech is almost never heard against a background of absolute quiet (except under laboratory conditions), it is important to know how background noise decreases speech intelligibility. A major factor in this consideration is the ratio of speech energy to noise energy. This ratio, called the signal-

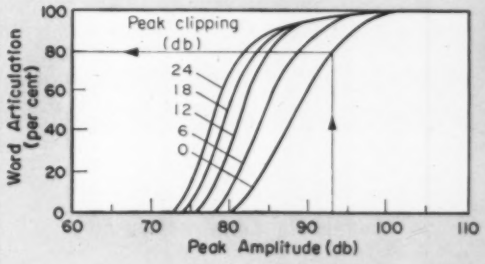


Fig. 8—If peak energy is clipped from speech sounds and the remaining energy amplified, speech is still intelligible. In fact, clipping actually increases speech intelligibility. As the curves show, unclipped speech with a peak-energy level of 93 db is 80 per cent intelligible. With 24-db clipping, intelligibility is still 80 per cent at a presentation level of 82 db

to-noise ratio (S/N), is expressed in db.

Fig. 7 shows speech intelligibility for various S/N ratios.[4] Note that for a given ratio, changes in intensity do not alter intelligibility very much. It is also seen that with a S/N ratio of 15 and a speech level of 80 db, about 85 per cent of the speech is intelligible. Surprisingly, about 40 per cent is intelligible even when the noise energy is 5 db higher than the speech energy (S/N equals -5).

It is felt that satisfactory communication of speech can be achieved if the speech level exceeds the noise level by 6 db.[4] Although this S/N ratio yields only about 75 per cent intelligibility, the redundancy in the English language permits satisfactory communication.

Chapanis[5] and Woodson[4] point out that human speech varies in intensity. Experiments have shown that when the peak energy is "clipped," speech is still intelligible, provided that the remaining speech energy is sufficiently amplified. Peak clipping of as much as 24 db will yield an intelligibility of about 90 per cent if the remaining energy is amplified so as to be presented at about 85 db. This phenomenon can be of value in communications-systems design, since the power capacity of the system need not handle the peak loads, Fig. 8.

▶ Noise

It is difficult to conduct conclusive experiments showing the effects of noise on the performance of workers in various jobs. It is generally agreed, however, that the presence of noise requires the worker to expend more energy to perform a task than he expends on the same task in the absence of noise. For some types of work, such as gross muscular tasks, noise seems to have no adverse effect on job performance. For precision work requiring fine coordination, however, extraneous noise tends to degrade performance. Frequently, it is found that noise inhibits performance for a short time, but that workers eventually adapt to it and their performance is then unaffected by the noise.

In general, noisy working environments give rise to undesirable psychological reactions in workers, and many investigators have noted increases in irritability, nervousness, and expressions of fatigue.

Prolonged exposure to high noise levels, for example, several hours a day for many months or years, has a deleterious effect on hearing. Steps have been taken to establish a basis for compensation of workers who can demonstrate that their working environment has contributed to their permanent hearing impairment. A considerable amount of work is also being done to develop protective devices that can be used by workers who must work in very noisy places.

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Tips and Techniques

Sheet-Steel Weight

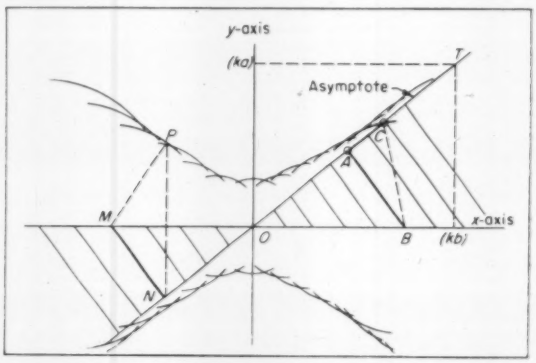
To compute the weight of steel sheet, multiply the thickness in inches by 40.8. The result is the weight in pounds per square foot. For example, if a piece of sheet steel is 0.005-in. thick, its weight is 0.005 × 40.8, or 0.204 lb per sq ft.—THOMAS C. ROSTRON, *Schramm Inc., West Chester, Pa.*

Hyperbola Construction

To construct a hyperbola of the form

$$\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$$

draw one asymptote through the origin, O, and point, T, whose co-ordinates are $x = kb$ and $y = ka$, where k is a constant chosen to give sufficient accuracy for the construction. Choose any segment $AC = a$ on the asymptote and draw AB perpendicular to the asymptote. With point B as a center,

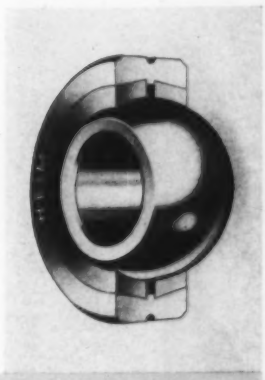


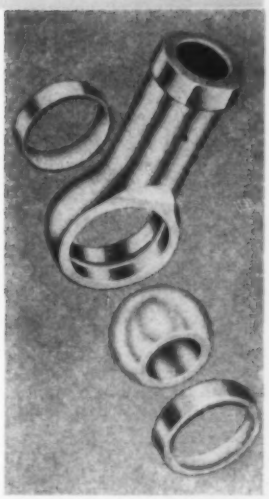
draw a circle through point C. Repeat the construction to give a number of circles. The circles thus drawn determine the envelope of the desired hyperbola.

To determine the normal to the curve at any point, P, draw PN perpendicular to the x-axis and NM perpendicular to the asymptote. Line MP is the normal to the curve at point P.— BYRON M. ROBINSON, *design engineer, Sutton Engineering Co., Bellefonte, Pa.*

Where and how to use

Plain Spherical Bearings





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Plain spherical bearings greatly simplify design problems requiring high-capacity, self-aligning bearings and rod ends, particularly in mechanical linkages. This article presents their design characteristics and suggests applications for which they are particularly well adapted.

A PLAIN spherical bearing consists of a sphere with centralized bore, the sphere being partially encased in an outer member of suitable bearing material, Fig. 1. The bearing is constructed in such a fashion that the highly finished sphere is used as a swaging die in forming the bearing surface and coins a corresponding finish into the mating surface. Upon completion, the sphere is free to turn in any direction within the outer member.

Fig. 1 — Construction of plain spherical bearings, showing cutaway view of cartridge unit, and exploded view of rod end. The highly finished sphere with centralized bore is free to turn in any direction within the outer member, which contains two bronze bearing surfaces

Fig. 2 — Right—Cartridge unit, commonly known as spherical bearing

Unibal bearings, the plain spherical bearings manufactured by Heim Co., are divided into three principal categories:

1. Cartridge units, commonly known simply as spherical bearings, Fig. 2.
2. Spherical-bearing rod ends, Fig. 3.
3. Integral assemblies with special devices of the designer's choice, Fig. 4.

Applications: Plain spherical bearings may be used in transmission of motion at varying angles between members where misalignment is caused by machining inaccuracies, or where members change position relative to each other. These bearings are widely accepted in the aircraft industry on control linkages, hydraulic and air-cylinder connectors, landing-gear shrink mechanisms, and in engine and airframe subassemblies.

A comparative newcomer in the entertainment and sporting world, the automatic pin spotter is largely dependent on spherical bearings for accomplishment of many complicated movements. One such machine uses over 25 rod-end bearings.

In automotive equipment, spherical bearings are used in power-brake linkages, windshield-wiper mechanisms, automatic door controls for public vehicles, and on carburetor-control linkages.

Textile-weaving and knitting machine manufacturers depend heavily on the high load-carrying capacity and ability of spherical bearings to compensate for rapidly changing alignment.

Fantastic demands placed upon the linkages of

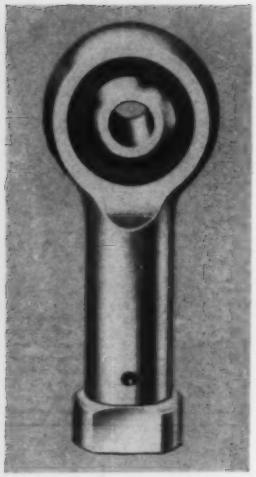


Fig. 3—Above—Spherical-bearing rod end

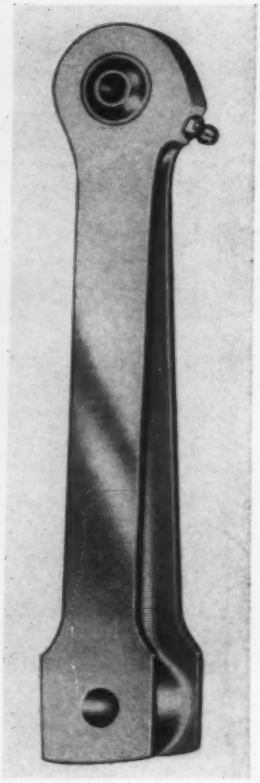


Fig. 4—Right—Spherical bearing mounted in special link furnished by user

automatic packaging machines as they fold, wrap, and pack containers require maximum design ingenuity. Design limitations have been greatly decreased by the ability of plain spherical bearings to misalign, oscillate, and rotate.

These few typical applications of plain spherical bearings indicate possibilities in other fields.

Limitations: Spherical bearings are applicable in any linkage where motion must be transmitted at constant or varying angles, or as supports to any device which is subject to mechanical or thermal deflection. The load-carrying capacity of spherical bearings and spherical-bearing rod ends is very high under static or near static conditions. It is several times higher than could be attained with comparable-sized antifriction bearings under dynamic conditions, providing that these conditions do not violate the limitations which a plain bearing imposes, and that adequate lubrication is maintained. However, plain spherical bearings are no more able to supplant antifriction bearings under conditions of high-speed rotation or oscillation at light loads than are antifriction bearings able to replace plain spherical bearings under high-static, low-speed loading.

In the bore-size range of $\frac{1}{8}$ to 2 in., spherical bearings carry static loads from 450 to 125,000 lb. Lowest load rating is that of a $\frac{1}{8}$-in. bore, male-threaded rod end having a low-carbon steel outer member, bronze bearing surface, and a through-hardened chrome-steel ball. Highest rating in the size range is attained by a spherical-bearing cartridge unit having heat-treated, alloy-steel outer member and bearing surface with a through-hardened chrome-steel ball.

Under conditions of oscillation or rotation, experience indicates that load-carrying capacity is reduced in proportion to the cube root of the speed. Also, speeds under 64 revolutions or oscillations per minute should reduce the load rating to one-fourth of the static allowable load.

Lubrication and Materials: Lubricant and material selection is a most important factor in designing a plain spherical bearing for operation under dynamic conditions. Allowable load ratings often exceed allowable pressure for presently available lubricants. Dry lubricants such as molybdenum disulphide bonded to the bearing surface with epoxy resin have proved serviceable under extreme high-pressure service.

Selection of bearing material is determined by conditions of load, speed, vibration, temperature, and contamination. The ideal combination of materials at normal temperature, medium load, where loading may be either static or dynamic, is a finely finished through-hardened ball in a bronze bearing. With this combination, friction and galling are minimized, and smooth operation for the majority of applications is assured.

Under conditions of heavier loads or moderate vibration, at temperatures below 500 F, steel may be used instead of bronze as the outer bearing material. With this combination, the tendency toward galling is much greater, but it can be minimized by chrome plating the ball, using a dry-film lubricant, or both.

Where loads become very great or vibration is severe and temperatures remain under 500 F, heat-treated alloy steel in the range of Rockwell C 26-32

Table 1—Materials for Spherical Bearings

Conditions	Recommended Materials*
Light to medium load, 350 F maximum temperature, minimum coefficient of friction, and smooth operation.	Bronze bearing surface with through-hardened chrome steel ball.
Light to medium load under shock or vibration, 500 F maximum.	Low-carbon or soft stainless steel bearing surface with through-hardened chrome steel ball.
Heavy loads under severe shock or vibration, 500 F maximum.	Heat-treated alloy steel bearing surface with chrome plated through-hardened chrome steel ball.
Light to medium load, 600 to 800 F, load to be determined by shock and vibratory conditions.	Soft 303 stainless steel bearing surfaces with through-hardened 440 C ball.
Heavy load up to 800 F maximum, with more severe conditions of shock and vibration.	Heat-treated stainless steel bearing surface (such as 410 or 416) and through-hardened 440 C ball.
Heavy loads at temperatures of 900 to 1200 F.	Stellite or Inconel X bearing surface and Stellite No. 3 or chromium carbide ball.

*Chrome plating of ball is optional under most operating conditions. Chrome plating produces a surface which is harder than the underlying hardened ball surface and therefore develops better wear characteristics.

is indicated for the outer bearing material. As in the case of low-carbon steel, use of chrome plating and/or dry-film lubricant may be necessary. So far, material selections have been based on low temperatures, i.e., 350 F maximum for bronze and 500 F maximum for steel. Where temperatures exceed 500 F, stainless steel becomes necessary for both ball and outer member.

Up to 800 F, a heat-treated 440C ball can be used with complete success in combination with a 303 stainless outer member, or if conditions require, a

Analysis of Permissible Misalignment

The following nomenclature is employed in succeeding equations to show how load ratings and permissible misalignment are determined for various spherical-bearing configurations:

a = Angle of misalignment for rod end
B = Bore of bearing
b = Angle of misalignment for spherical bearing
D = Diameter of outer race or head of rod end
E = Ball or inner race diameter
H = Width of outer race or head
J = Outer diameter of shank of female rod end
N = Diameter of hole in shank of male rod end
O = Diameter of flats on ball or inner race
R = Radial static load of bearings
S = Strength of shank of rod ends
T = Strength of head of rod ends
W = Width, flat-to-flat on ball or inner race
X = Proportional limit of material
for steel, 80 per cent of low yield point, 52,000 psi for low carbon steel, 140,000 psi for 4130 steel
for bronze, 30,000 psi for Naval bronze, 35,000 psi for aluminum bronze
Y = Shearing factor of material
30,000 psi for Naval bronze, 35,000 psi for aluminum bronze

Diameter of ball or inner race is

$$E = \sqrt{O^2 + W^2}$$

Maximum static load of a rod end is the smallest of three following factors:

1. Radial load
$$R = 1.0472 \times E \times H \times X$$
2. Strength of head
$$T = (D - E - 0.176H) \times H \times X$$
3. Strength of shank
Male thread
$$S = [(\text{root diameter}^2 \times 0.7854) - (N^2 \times 0.7854)] \times X$$
Female thread
$$S = [(J^2 \times 0.7854) - (\text{outside diameter of thread}^2 \times 0.7854)] \times X$$

Axial load for a bearing or rod end is determined as follows:

$$\text{Axial load} = 0.7854Y\,[(E + 0.176H)^2 - E^2]$$

Angle of misalignment in a rod end is controlled by outside diameter of the head. Maximum degree of misalignment is obtained when the head of the rod end contacts the side of the fork in which it is mounted. Angle of misalignment is determined as follows:

$$a = \sin^{-1}\frac{W}{D} - \sin^{-1}\frac{H}{D}$$

Angle of misalignment in a spherical bearing is found somewhat differently from that of a rod end because of the difference in configuration. There are three types of mountings for these bearings, as shown in the illustration. Angle of misalignment for each of these types is determined by the following equations, where $V = [(D - 2C)^2 + H^2]^{1/2}$:

$$b_1 = \sin^{-1}\frac{W}{V} - \sin^{-1}\frac{H}{V}$$

$$b_2 = \sin^{-1}\frac{W}{E} - \sin^{-1}\frac{H}{E}$$

$$b_3 = \left(90\text{ deg} - \sin^{-1}\frac{B}{E}\right) - \sin^{-1}\frac{H}{E}$$

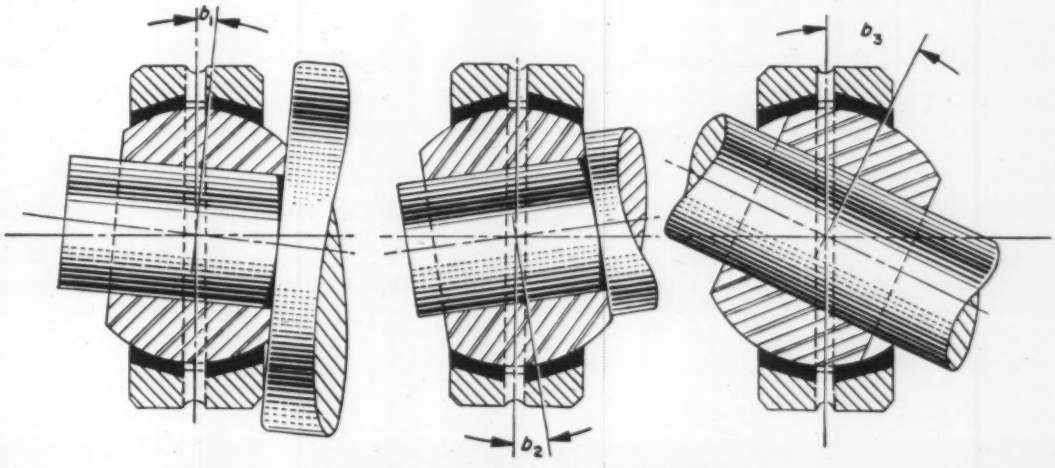


Fig. 5—Three types of mountings for plain spherical bearings showing angle of misalignment for each

heat-treated 400 series stainless in the hardness range of Rockwell C 26 to 32. Again, chrome plating and/or dry-film lubricant is often essential to successful operation.

Over 800 F and up to 1200 F, with or without corrosive atmosphere, balls of Stellite No. 3 and chromium carbide have been used in combination with Stellite or Inconel X for the outer member. These materials are not suitable for the swaged construction usually associated with spherical bearings and require either loading-slot construction where a slot is broached in the outer member to permit sideways insertion of the ball, or various modifications of this design. Though bondable dry-film lubricants are available for temperatures up to 1100 F, experience indicates that operation without lubricant is more successful.

For chemical-processing equipment and food-handling machinery where frequent cleaning is required, completely stainless bearings are customarily used. In this type of application, the bearings are frequently operated without lubrication to prevent possible process contamination. Cadmium plating of parts which contact food, and milk in particular, is not allowable because poisonous products result from the reaction of cadmium with food or milk acids.

For most normal-temperature applications other than aircraft, the most successful lubricant has been a high-pressure gear lubricant, such as Lubriplate 130AA. For aircraft, the use of grease to specification MIL-G-3278 is mandatory in most applications at temperatures of − 65 to 250 F.

To summarize, principal material selections for spherical bearings are listed in Table 1.

Design Considerations: Conditions under which a spherical bearing or spherical-bearing rod end is mounted are decisive in determining the degree of misalignment which can be attained. Methods of determining load ratings for various bearing configurations and the method of calculating permissible misalignment under various operating conditions are shown with Fig. 5.

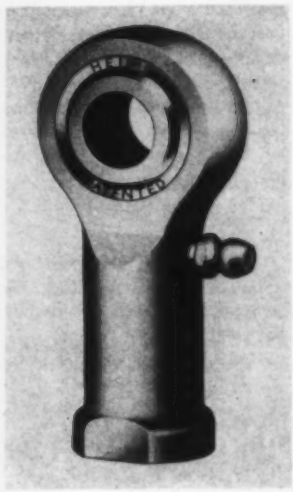


Fig. 6—Standard lubricating fitting installed on rod end for relubrication

These formulas are applicable only to push-pull loads, since loading of any other type would introduce a bending moment in the shank, and that load would be a function of the direction of the load and the length of shank exposed to the load. Cataloging of load ratings beyond those which apply to push-pull applications is impractical, and loadings which impose bending require individual consideration.

Spherical bearings are normally supplied with a grease groove on the outside diameter. This groove connects to a cross-drilled hole that directs the lubricant to a grease reservoir at the center of the bearing area. Bearings are prelubricated at the factory and provision for relubrication must be provided in the design of the housing.

In the case of rod ends, both male and female, relubrication can be accomplished through the shank, or a standard lubricating fitting, Fig. 6, can be inserted into the outer member of the rod end at a convenient location.

Tips and Techniques

Storing Brown-Line Paper

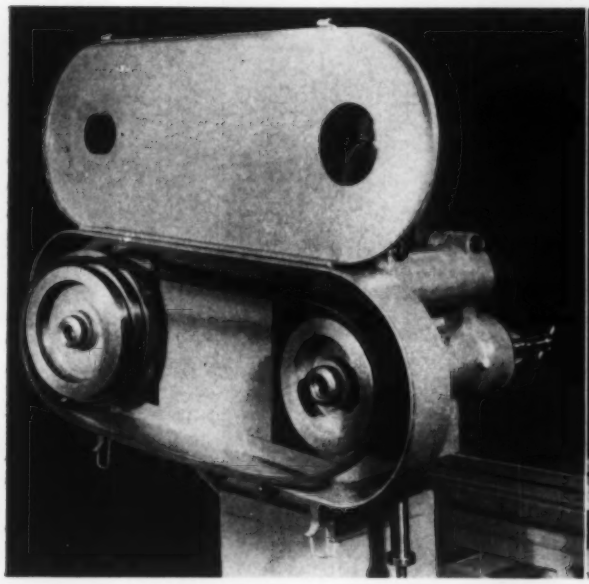
At one time, our blueprint department stocked brown-line, dry-print, sensitized transparency paper in the popular A, B, C, and D-size cut sheets, as well as roll stock. After a few weeks, there would be an inevitable loss of unused stock due to slow, accumulated exposure, rendering the paper useless.

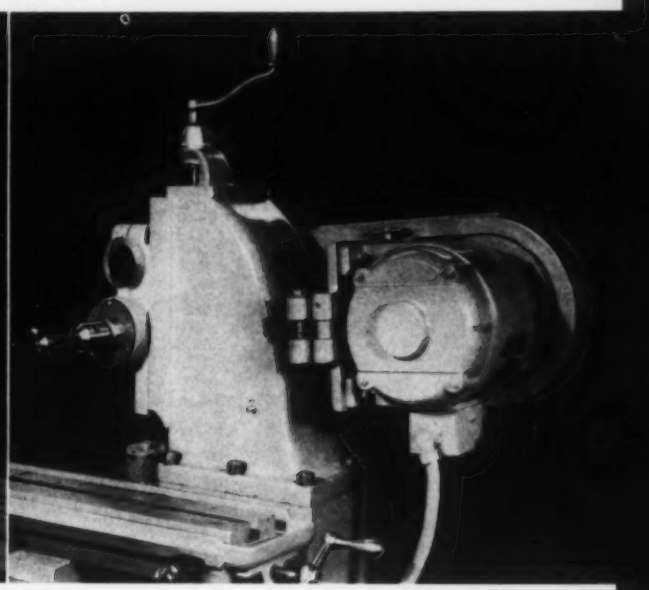
After several such experiences, the cut sheets (except the much-used A size) were discontinued in the interest of economy. In their place, the roll stock was substituted, resulting in excessive waste of time and material caused by cutting and trimming.

Recently, our problems were solved by introducing a zippered envelope, sized to accommodate a package of D-size paper. The envelope material is Naugahide, used in automobile upholstery, which is completely lightproof. For maximum convenience, the envelope has a continuous zipper across one side and one end. The envelope was custom made in an automobile seat-cover shop for a modest $14.

An advantage of this scheme is the convenience of safely leaving the envelope lying out within easy reach near the machine. Any sheet size is readily obtained by folding and tearing the D-size sheet into B or C sizes, which are even fractions of the D sheet.—Ed L. Gordan, *Fairchild Engine & Airplane Corp., Stratos Div., Manhattan Beach, Calif.*

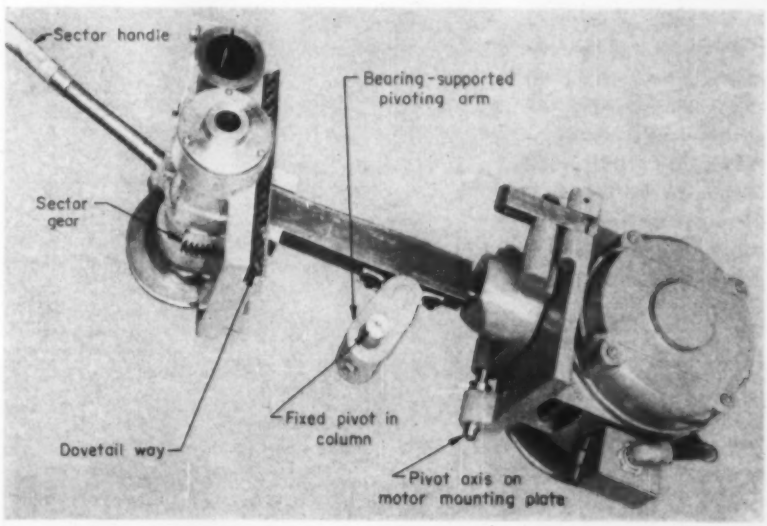
Pivoted Motor-and-Head Mounting Offers Sensitive Up-and-Down Adjustment





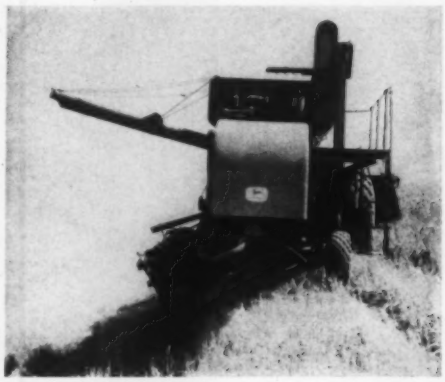
CONSTANT CENTER DISTANCES between sheaves on drive motor and tool head in a new milling machine are provided by a pivoted mounting construction. As reported by Fred Hirsch, engineer, U. S. Burke Machine Tool Div., Brotherton Road and Pennsylvania Railroad, the head and motor are balanced on a common, bearing-supported pivoting arm. This method of design provides for a sensitive vertical movement of the milling head, which is rack-and-pinion feed.

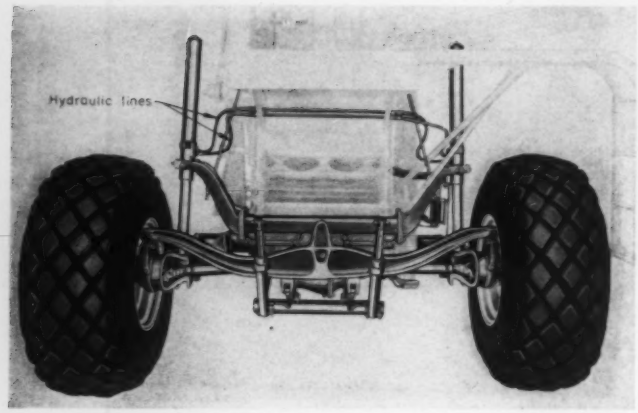
UP-AND-DOWN ADJUSTMENT of milling head is accomplished manually with the sector handle. The dovetail way on the head slides in a dovetail in the machine column as the motor and head are pivoted about the fixed pivot. The motor is also designed to swivel about the pivot axis on the motor mounting plate to facilitate belt changing on the step pulleys.



Automatic Hydraulic Leveling System Permits Machine Operation on Slopes

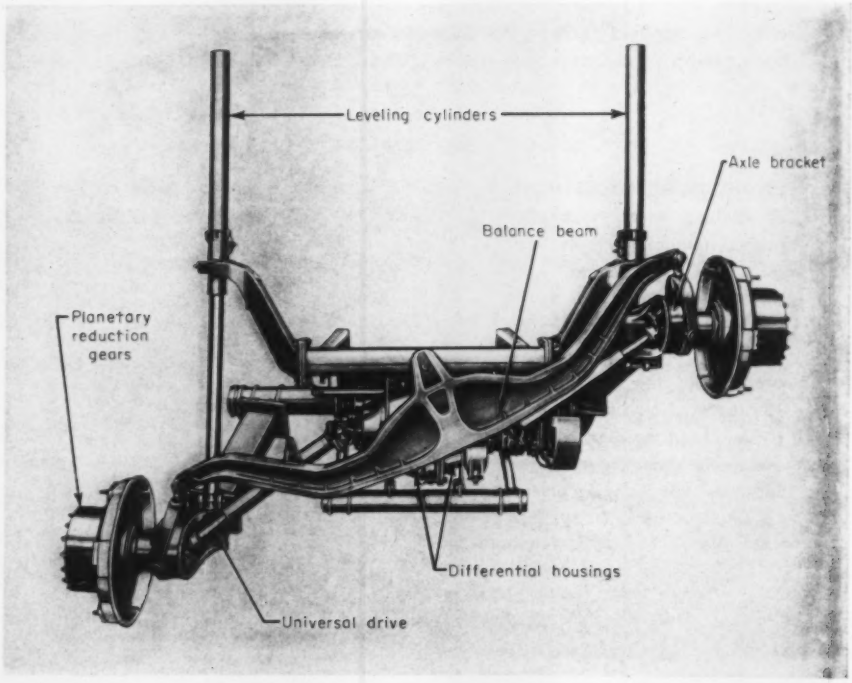
SELF-PROPELLED, SELF-LEVELING combine is designed to harvest grain on steep hillsides. The John Deere mobile separator can be safely operated by one man with excellent control of cutting height. This view shows the rear steering wheels.



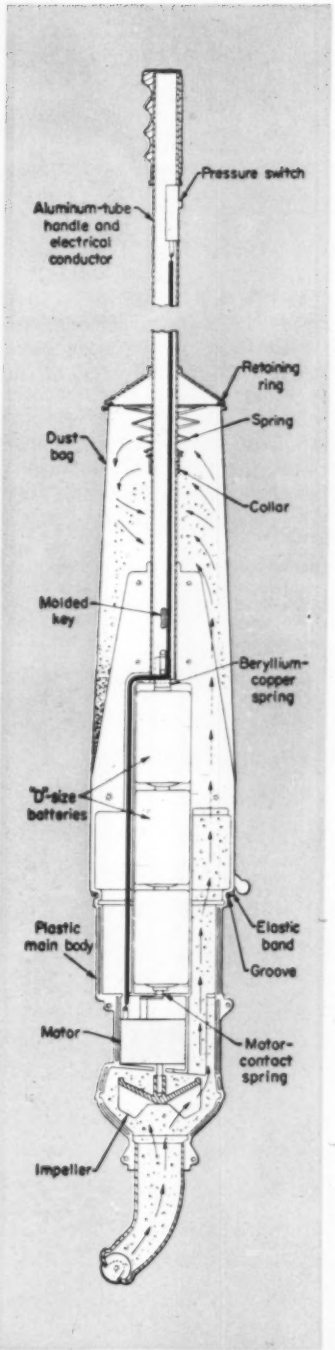


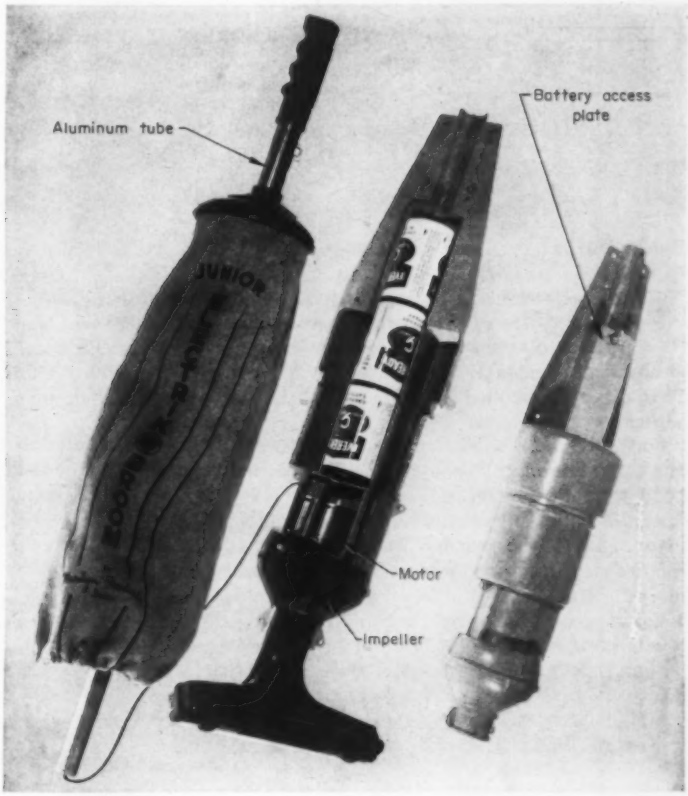
MAXIMUM PERMISSIBLE TILT of drive wheels by the leveling mechanism is 37 per cent. The balance beam carries the combine pivots at the center to keep leveling cylinders synchronized. The axle brackets support the lower end of the leveling cylinders.

LEVELING MECHANISM on front drive wheels is operated by hydraulic cylinders which are controlled by an automatic fluid-level sensing system. In the event of an electrical or hydraulic failure in the system check valves automatically lock the hydraulic leveling rams to hold the combine in safe relation to the slope. If the automatic controls cut out, the hydraulic leveling assembly can be operated manually.



Handle Doubles as Electrical Conductor in Battery-Powered Vacuum Cleaner





ALUMINUM-TUBE HANDLE makes up part of the electrical circuit in a battery-operated toy vacuum cleaner manufactured by Marilyn Products Co. The tube in the machine, which was designed by Arnkurt Associate Engineers, makes contact by means of a beryllium copper spring with the negative pole of one of three 1½-v batteries. One terminal of the pressure-switch control is connected to the tube and the other to one brush of the dc drive-motor commutator. The other side of the motor is connected to the positive pole of the group of three batteries. Motor operates on 4½ v and develops 0.0015 hp at 6300 rpm.

MOLDED IN TWO HALVES, the plastic main body of the cleaner is designed for easy assembly, with separate compartments for batteries, motor, and impeller. The tube handle is secured by a half-round groove in each molded part and positioned by a molded key, which fits into a punched slot in the tube.

The dust bag is attached to the main body by an elastic band seated in a groove. The other end of the dust bag is held by a retainer ring, which slides on the aluminum tube. The bag is held firm by a spring, mounted between the retainer ring and a collar on the tube.

Designer's Guide to

Honeycomb-Sandwich

By ANDREW MARSHALL
General Manager, Application Engineering
Hexcel Products Inc.
Oakland, Calif.

THE recognized advantages of honeycomb cores for high-strength, low-weight structural sandwiches, plus the fact that design engineers are specifying increasingly complex sandwich constructions, have accelerated development of honeycomb-fabrication techniques.

Formerly, such sandwiches generally were fabricated by laminating two outer skins of metal or wood to a flat honeycomb core to form a constant-thickness panel. Recently, however, strength-weight advantages of honeycomb sandwiches have been adapted to structures with simple and compound curves. New core and skin materials, plus new bonding techniques, offer many different fabrication possibilities.

Honeycomb core, in a sense, exists in two states. Before fabrication in a sandwich, it is extremely flexible with seemingly little strength or body, Fig.1, and requires care in handling to prevent crushing or damage to individual cells. However, once incorporated in a sandwich, the core becomes the structural center of a solid, rigid panel which has strength and dimensional stability.

▶ Honeycomb Sandwiches

Honeycomb-core panels are constructed by bonding two facing sheets or skins of metal or veneer to the lightweight core so that they close off the holes in the honeycomb. The result is a three-ply structure in which the walls of the individual cells act as hollow, shear-resistant columns holding the two facing materials apart.

In an ideal honeycomb sandwich, the individual parts (core and skins) should all fail under load at approximately the same time. Sometimes, "ideal" sandwiches have extremely thin-gage skins. Such skins are subject to puncture and tearing under relatively low loading at concentrated points. Consequently, skins on these panels are overdesigned relative to required structural strength of the panel. However, the skins have a rigidity of their own. When they are shaped to fit the core, precision techniques must be used to achieve a good bond between the inner face of the skin and edges of the individual core cells.

Materials Selection: Skins and honeycomb core may be made of the same material (e.g., aluminum, steel, fiberglass-reinforced plastic, or paper) or they

Fig. 1—Honeycomb core before fabrication in a sandwich panel. In this state, the core is extremely flexible and requires careful handling to prevent damage to cells. Strength and dimensional stability are imparted to cores by addition of outer skins

Structures

- Honeycomb Sandwiches
- Core Materials
- Facing Materials
- Parallel Surfaces
- Contoured Surfaces
- Joining and Interconnecting Cores
- Skin Attachment
- Fasteners

may be of quite dissimilar materials. For example, a reinforced-plastic honeycomb core in an aircraft wing panel may be faced with aluminum. In curtain-wall panels for office-building construction, aluminum honeycomb cores may be combined with an enameled-steel exterior face and a thin interior steel layer.

Generally speaking, both skin and core materials are chosen for their performance in a known environment or application, with due consideration for structural strength as a function of cost.

Core Materials

The three most common types of material presently used in honeycomb cores are paper, fiberglass-reinforced plastic, and aluminum. Stainless-steel honey-

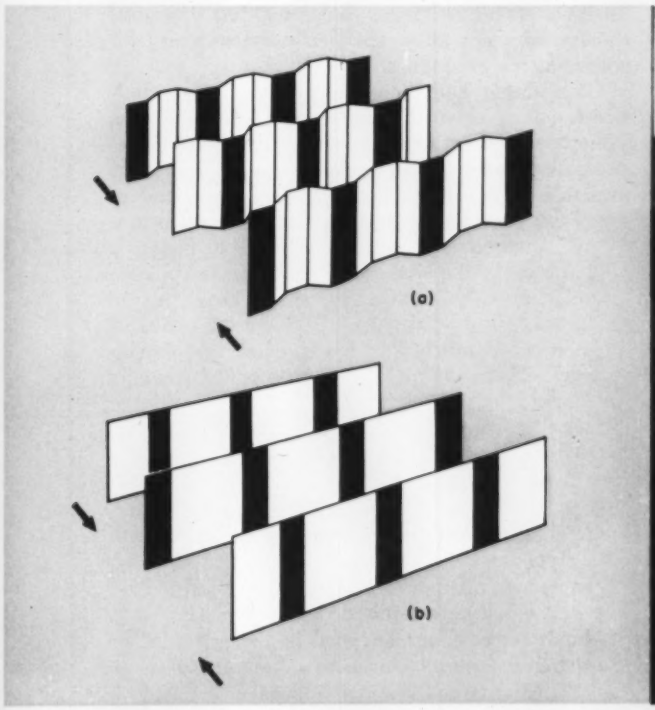


Fig. 2—Core-forming methods. Corrugated strips of core material, *a*, are bonded to form shaped hexagonal-cells. Alternatively, flat strips of core material, *b*, may be bonded to form a "solid" block. This unexpanded core can be machined by conventional methods and then expanded to final shape

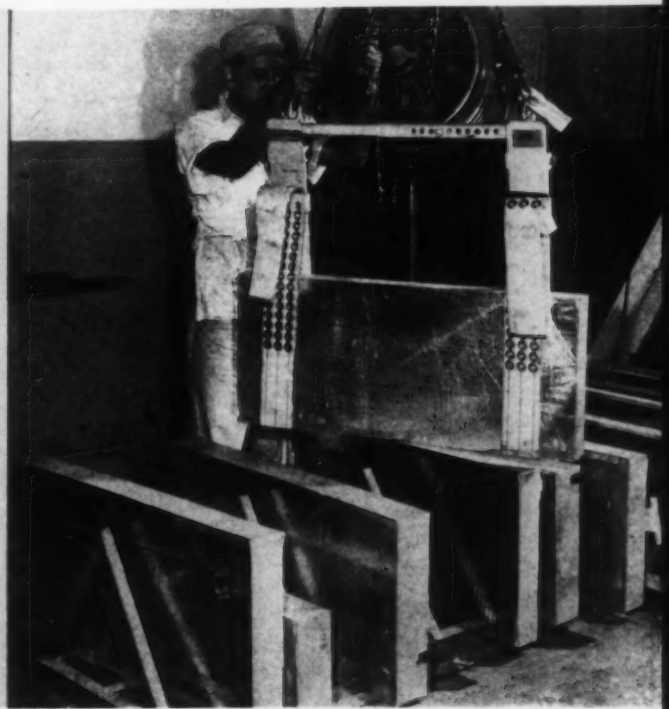


Fig. 3—Unexpanded paper-core honeycomb. Convenience of handling and storage is the main advantage of unexpanded cores of fragile material. Possibility of cell damage is remote

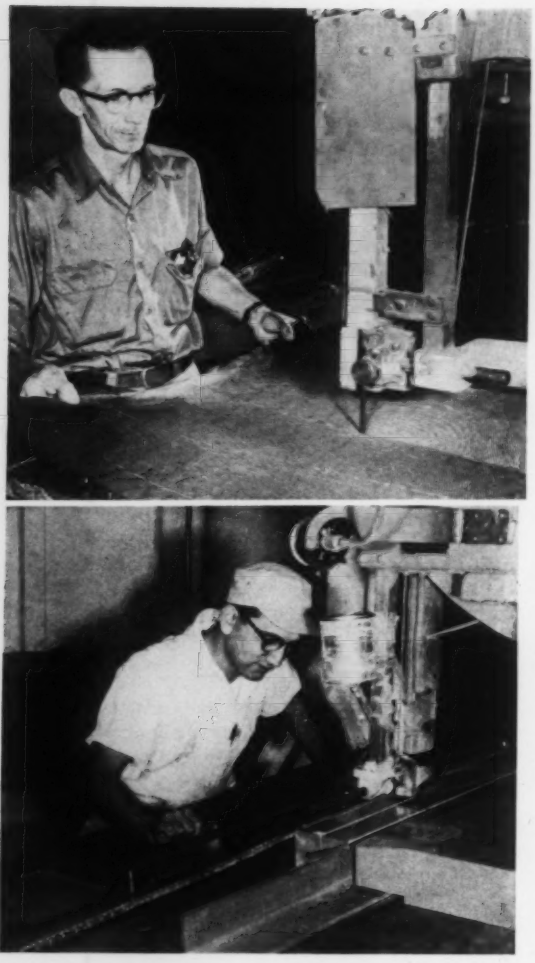


Fig. 4—Above—Bandsawing expanded, *a*, and unexpanded, *b*, honeycomb core. This is the method most commonly used for cutting cores to size. Feeding expanded core at an angle to the blade facilitates cutting by providing a uniform and constant load on the saw

Fig. 5—Below—Cutting and grooving operations performed on expanded honeycomb core on a table saw

comb is used in certain critical high-temperature applications, and experimental work is being done on titanium and super-alloy core materials for high-temperature use. Impregnated cotton cloth has been used in certain applications in the past.

Core Forming: Honeycomb cores are usually formed in one of two ways, Fig. 2. Strips of the material from which the core is to be made may be corrugated and bonded so that each corrugation forms one-half of a hexagonal cell. The other method involves bonding a number of flat, thin strips of material in such a way that when the strips are pulled apart and expanded, hexagonal honeycomb-cells are formed. When the strips are pulled far enough apart to form rectangular cells, the process is called overexpanding. Overexpanded glass-plastic core is sometimes used for special panel designs because of its characteristic of bending easily in one direction (along the width of the cells) but not in the other. Hexagonal cells also have a greater rigidity and strength in one direction than in another since continuous strips or "ribbons" of core material exist in only one direction.

Core Forms: In the expanded state, core cells are completely formed, while in the unexpanded or HOBE (HOneycomb Before Expansion) state, the core appears to be a solid block of material. All core materials are available in the expanded form and some of them, such as paper, aluminum, and stainless steel, can be obtained in the HOBE state.

Convenience of handling and storage is the primary advantage of using HOBE paper core, Fig. 3. The main advantage in using aluminum HOBE is that certain machining operations can be easily performed on the core in this form. Glass-plastic core is not supplied in the unexpanded form because the amount of impregnation necessary for structural rigidity does not allow the flexibility necessary for collapsing or expanding.

Glass-plastic honeycomb is made of glass cloth which is impregnated with plastic, fabricated to a honeycomb structure, expanded, cured, and repeatedly coated with additional resin. It is generally available in cell sizes from 3/16 to 3/4 in. and in panel thicknesses from 0.060 to 18 in. Core densities for these materials vary from 2.5 to 12 lb per cu ft and, for each cell size, can be varied over a considerable range with different weaves of cloth and amounts of dip-coated resin. Glass-plastic materials are normally furnished in blocks or slices although some manufacturers mold them to specified contours for ease of application.

Low-cost, paper-core material is usually impregnated with a phenolic resin. Cell sizes generally vary from 7/16 to 1 in. and core thicknesses from 1/4 to 6 in. Depending on core thickness and amount of impregnation, density varies from 1.8 to 4.0 lb per cu ft. Because of its low conductivity, paper honeycomb-core is often used in panels where low heat-transfer is required.

Aluminum cores are supplied in the expanded or unexpanded form in thicknesses from 0.060 to 30 in. By varying cell size and foil gage, honeycomb

density can be closely controlled over a rather wide range. Aluminum core is available in 1/8 to 3/4-in. cell sizes in densities ranging from 1 to 8.1 lb per cu ft. Core is supplied with small perforations in the cell walls to permit evacuation of solvents during panel fabrication.

Facing Materials

In load-carrying applications of sandwich structures, facing materials carry the main portion of the bending load and the core carries most of the shear. This becomes evident from the comparison of a honeycomb panel with a solid beam. In the solid beam, outer fibers in tension and compression carry the major portion of the load. Bending stresses are relatively small near the neutral axis. By using a low-density material of adequate shear strength near the neutral axis and two solid layers of high-strength material near the surface, load carrying properties of the solid beam can be duplicated at considerably less weight.

Facing-material characteristics greatly influence stiffness, stability, configuration, and strength of honeycomb sandwiches. In addition, the facing exterior sometimes provides special outer effects as in nonskid flooring or decorative panels. Certain embossed surface treatments are sometimes used to strengthen facing material.

Basically there are two types of facings: Strong and rigid facings such as wood, plywood, reinforced plastic, and metal; and less rigid facings such as fabric or mat that is "wet laminated" into place with resin to supply some rigidity and bonding to the core. Selection of either of these types is, of course, determined by the specific application involved. Extreme care must be taken during handling and fabrication to prevent denting or wrinkling face materials. Because one of the two skins is usually stressed in compression, defects could cause premature failure by buckling.

Metallic Facing: Aluminum alloys such as 7075-T6 and 2024-T3 are commonly used as facing materials in thicknesses from 0.01 to 0.064 in. in both structural and nonstructural applications. An anodized finish or a protective resin coating can be applied where corrosion resistance is required.

Steel is used in some applications for facing on honeycomb sandwiches. For example, stainless steel and porcelain-enameled steel have proved successful in exterior building panels.

Nonmetallic Facing: Resin-impregnated glass cloth can be used as a facing material for structural applications. A wide range of directional strengths can be obtained by proper choice of cloth-weave resin and proper orientation of cloth fibers.

Glass-fiber mat, another commercially available surface material, is similar in final appearance and function to glass cloth. However, glass cloth provides a higher strength and smoother surface with a more consistent facing thickness than mat.

Resin-impregnated paper facing materials have been used in flat, nonstructural panels such as interior walls and partitions. In applications where highly concentrated loads might occur, impregnated-paper facings are highly susceptible to tearing and puncturing.

Plywood, as a facing material, has found wide use in both structural and nonstructural honeycomb-sandwich applications. One nonstructural application, for example, uses plywood facings on paper honeycomb-cores for interior and exterior doors.

Fig. 6—Milling unexpanded metallic honeycomb- core. Flat surfaces are easily machined by conventional milling methods and uniform tapers are produced most efficiently in this way. Milling techniques can be adapted to shape unexpanded paper-cores

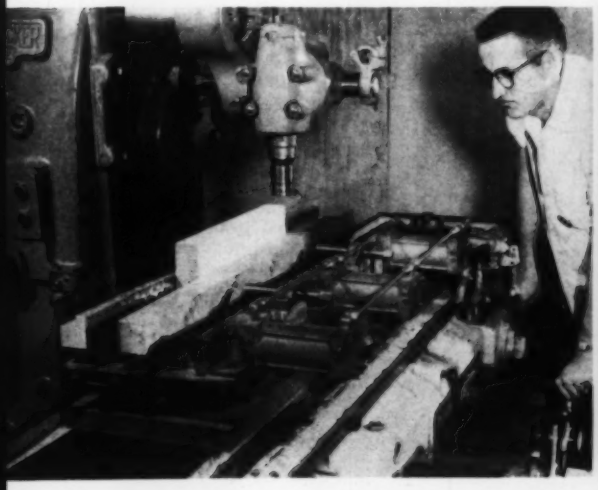
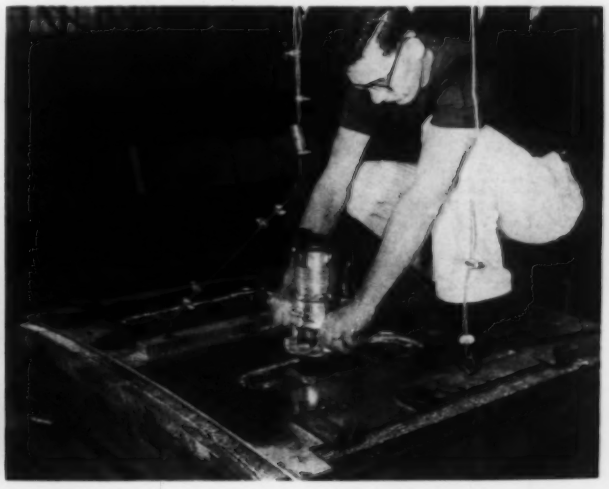


Fig. 7—Shaping honeycomb core by routing. The router is guided by a jig to decrease edge thickness of the core prior to bonding. This hand operation is satisfactory for core thicknesses to 2 in. Straight, clean cuts with a router are difficult in thicknesses greater than 2 in.



Parallel Surfaces

Bandsawing is the most common method of cutting or shaping all types of core materials with parallel edges and faces. Milling, stamping, planing, sanding, and grinding are also used in some instances.

The bandsaw is used primarily for general cutting-to-size of expanded core, and unexpanded core from large blocks, Fig. 4. Sawing expanded core, in a direction parallel to cell sides, is facilitated by feeding the core at an angle to the blade rather than perpendicular to it. In this way, instead of cutting through metal, adhesive, and air in sequence, the saw passes through all of these at the same time. This angle-feed provides a constant load on the saw and results in an evenly cut edge. Another type of sawing operation, performed on a table saw, is used to cut grooves and notches in honeycomb core, Fig. 5.

Milling: Parallel faces may also be machined by milling the core in the HOBE state, Fig. 6, although milling is most often used to cut flat, tapered planes. Where uniform taper is required, milling the unexpanded internal core is often an efficient way of producing the taper. Uniform taper is essential in the construction of certain panels because extremely flat surfaces are necessary for the best bond.

For tapered and parallel surfaces, milling is usually performed on unexpanded metallic honeycomb materials although it could conceivably be done on unexpanded paper cores. Flat surfaces are generally not milled but are cut to shape on high-speed bandsaws. The HOBE milling process is quite accurate, but final tolerances on the tapered and expanded core are greatly dependent on the accuracy and consistency of the expansion characteristics of the core. If the stripe width and location of the bonding adhesive for holding the core together are not held accurately, the core will not always expand to final specified dimensions.

Stamping: Stamping with a steel-rule die is used to shape parallel edges of all types of honeycomb cores. Steel-rule die stamping is usually done only when core-cell size is less than $\frac{3}{8}$ in. For aluminum cores, two other factors which influence selection of this type of stamping are core thickness and gage. Light-gage cores less than 1 in. thick, or heavy-gage cores less than $\frac{3}{4}$ in. thick, are suitable for the stamping operation. Stamping with a steel-rule die is generally used for high-volume production.

Production of accurately dimensioned core shapes, such as those required in large truck-body panels, is speeded by stamping. Panels of this type have edge cut-outs to accommodate wheel wells, hinges, and other discontinuities in the panel surface. Cut-outs for such areas in these panels are accurately and uniformly made with the steel-rule die so that no time-consuming core fitting is required at the time of panel assembly and bonding.

Hand-Tool Operation: Routing and knife-cutting, both hand-tool operations, are two other means for shaping the outer periphery of honeycomb core. The router bevels or tapers core thicknesses to approximately 2 in. using a circular-knife type of cutter, Fig. 7. For thicknesses greater than 2 in., knife cutting is recommended because the router is difficult to guide for straight, clean cuts. The core is placed in a case-hardened, rubber-faced guide jig, and the knife is simply drawn around the outer edge with an up-and-down slicing action, Fig. 8.

For relatively low production of honeycomb panels, such as those used in custom desk tops, knife cutting is most efficient. In this application the panel size is not too large, so handwork required in cutting the core to shape is not too costly.

Contoured Surfaces

A bandsaw can be used to cut simple contours in honeycomb-core material by modifying the saw so that the blade cuts horizontally. The blade guides, or entire saw-frame, rest on two contour bars, Fig. 9. As the saw moves into the core, it follows the path provided by the contour bars to produce a curved surface with straight-line elements.

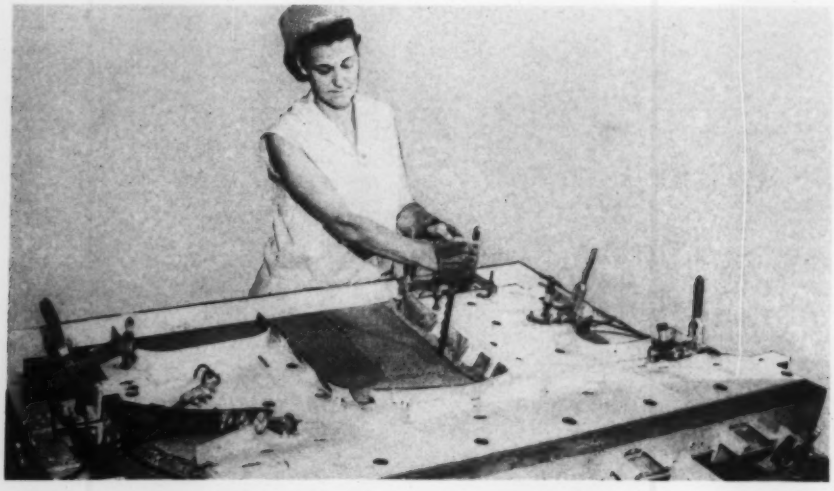
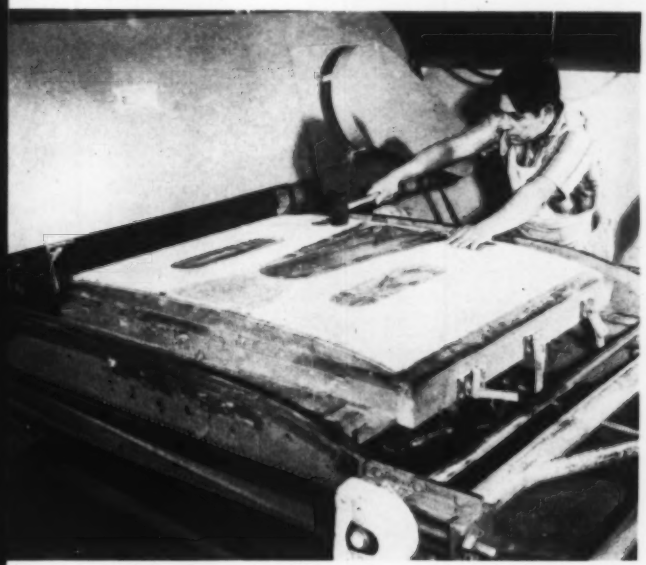


Fig. 8—Knife-cutting for shaping cores thicker than 2 in. The knife is guided by a case-hardened, rubber-faced guide jig. An up-and-down slicing action produces a clean cut. This operation is feasible for low-volume production of small panels

Rolling: Sheet-metal roll-forming machines form simple, contoured cores with parallel sides, Fig. 10. This forming process works best with metallic cores. Radius of curvature that can be obtained on such a rolling machine is directly proportional to thickness of the core. If the curvature of the finished panel is too severe to be formed on this machine, several thinner pieces of the core which have the required contour can be laminated to obtain the necessary thickness and final contour. This type of laminated-core structure has been found to be stronger than a single piece contoured to the same shape.

Where it is necessary to maintain continuity of panel strength around a curved surface, such as that of the leading edge of an aircraft wing, the rolling operation for core forming is highly advantageous. In this application, the curve must be kept smooth and exact to obtain a good fit for bonding and to maintain aerodynamic properties from one wing to the next during production.



Planing and Milling: Planing is sometimes used to machine simple and compound contours. The machine for this type of operation is a tracer-controlled skin mill which operates on a 3D, pantographic principle with the cutting tool guided by a master pattern through hydraulic linkages. Planing is usually performed on expanded honeycomb with a filler material in the core cells. To mill the core material in the expanded form, individual cells are filled with a material to give the honeycomb enough body to keep the face from being damaged by burring, crushing, or tearing. This type of milling is usually performed only on metallic cores, but can also be performed easily on glass-plastic cores. The most common fillers are waxes, water-soluble materials like polyglycol, and ice.

Before milling, the entire core is filled with a suitable filler material. After milling, a wax filler may be removed by heating, or a water-soluble filler may be removed with a water spray. Since the core must be placed in an oven one or more times to remove a wax filler, the water-soluble filler is usually considered the easier of the two to use. When ice is used as a filler material for milling expanded cores, the machine tool is equipped with a refrigerant system which keeps the ice solid and freezes the core to the chuck. Removal of the ice subsequent to machining is, of course, very simple.

Contoured surfaces are also produced by milling unexpanded cores. Here again, the expanding operation is critical and determines final contour and dimensions, Fig. 11.

In the production of concave and convex sandwich

Fig. 9—Above—Modified bandsaw for cutting simple contours in honeycomb cores. The blade is guided horizontally by contour bars to produce a curved surface with straight-line elements. Operator is using a rubber mallet to seat the honeycomb against the back surface of the saw contour fixture

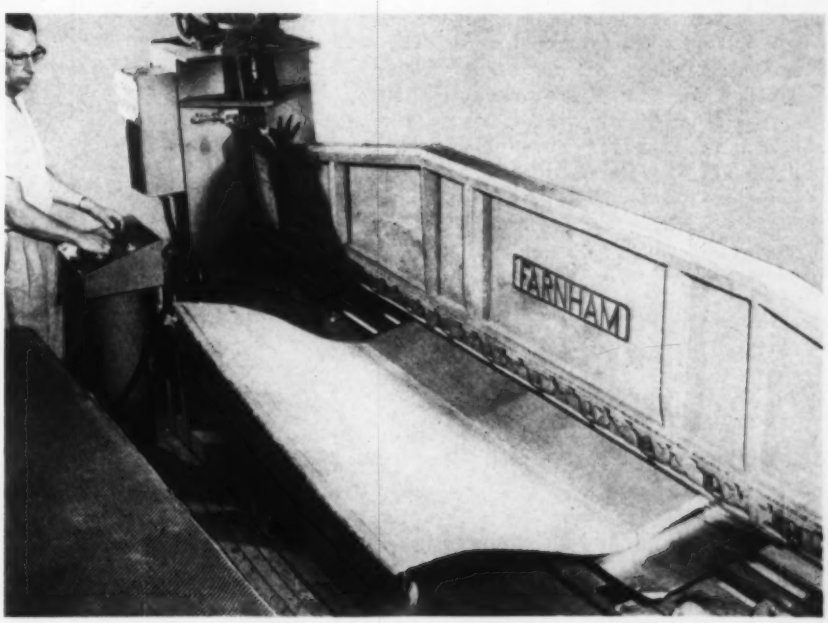


Fig. 10 — Right — Sheet-metal roll-forming machines for rolling simple contours in metallic honeycomb. Radius of curvature possible with such a machine is directly proportional to core thickness. If required curvature cannot be produced this way, thinner pieces of curved core can be laminated to obtain final contour

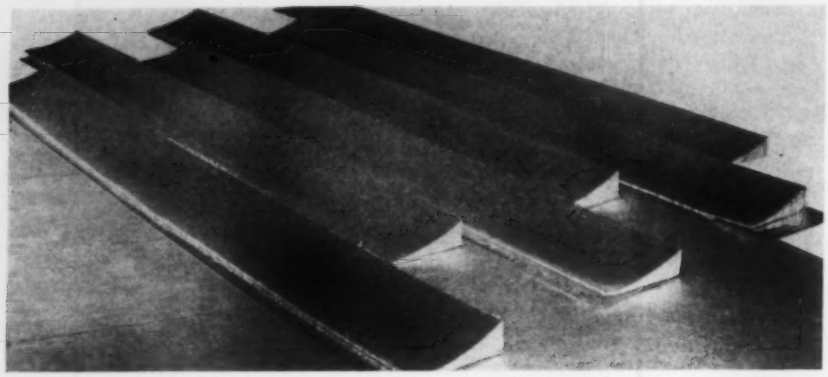


Fig. 11 — Contoured surfaces produced by milling unexpanded cores. Although milling is accurate, final tolerances on the expanded core depend on the consistency of expansion characteristics of the core. Stripe width and location of bonding adhesive are critical

panels for aircraft or other special applications, planing of filled honeycomb provides a highly automatic and accurate means of shaping the core. However, core dimensions must be particularly accurate for the best possible mating between surfaces of the core and facing materials. If core and face do not mate at any one point, the panel is liable to fail at this unbonded portion under subsequent loading and environmental conditions.

Other Contouring Methods: Other types of equipment have also been adapted to machine filled-honeycomb core. For example, a contour-duplicating machine, Fig. 12, is used to machine aluminum cores for aircraft honeycomb-sandwich panels. As with planing, the core is worked in the expanded form with ice as the filler material in the cells.

The Anocut process has been used successfully for forming complex contours on the surface of expanded-honeycomb cores without fillers. Anocut is a reverse-plating process that takes place in the presence of an electrolyte and is, at the present time, best adapted to contouring stainless-steel cores in which core ribbons are spot-welded together rather than adhesive bonded. Because the adhesive in other metallic honeycombs is nonconductive, the reverse-plating process is troublesome. The Anocut technique is being used to contour stainless-steel honeycomb cores for high-temperature applications.

Elox is another electrical process for contouring honeycomb cores. This process utilizes the principle of electrical disintegration to erode core material by sparking or burning. Machining by electrical erosion is slow but very accurate for such jobs as broaching holes into which a forging, fitting, or casting is to be sunk.

Paper or glass-plastic honeycombs can be contoured simply by molding or post-forming the contours in the nearly cured state. In this process, cores are preheated, placed in contoured molds under contact pressure, and allowed to cool. Cores to $\frac{5}{8}$ in. thick by 6 ft long are precurved in this manner after being pulled into place in the mold by a vacuum press and then bonded to a smooth contour. If, however, the section is thick or the piece has sharp-angle curves or corners, it is necessary to cut the core into small segments and fit them together in the mold for bonding, Fig. 13.

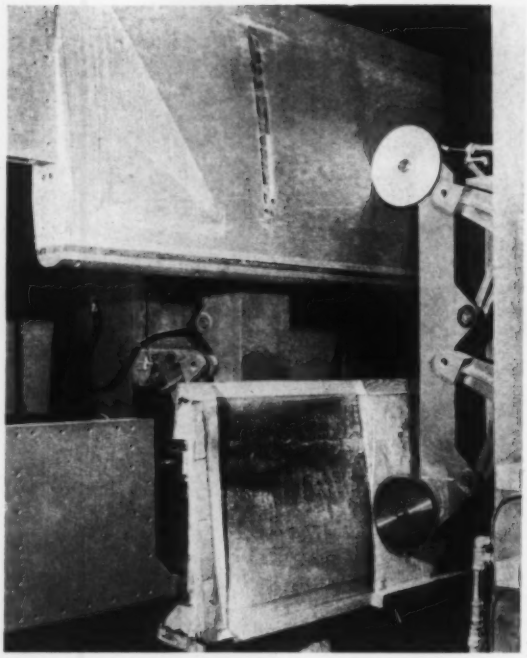


Fig. 12—Contour-milling expanded and filled honeycomb core. Cells are filled with water which is frozen to provide enough rigidity to prevent cutting, burring, and tearing of the machined surface

A similar technique involves molding segments of glass-plastic or paper core to shape by placing them on a layer of resin-dipped glass cloth which serves as one face of the panel. Another layer of cloth is then bonded to the other side. There is usually no need to bond the segments, since the core-to-face bond is sufficient for most structural requirements. This technique is particularly well adapted to high-volume production since no separate step is involved in bonding individual segments.

Compound contours, formed by either molding a whole section or by combining segments, provide excellent structures where both light weight and high strength are needed. Panels of this type are used in the construction of racing and pleasure boats. Sides of the boat are formed by standard glass-cloth lamination techniques and the bottom, where higher

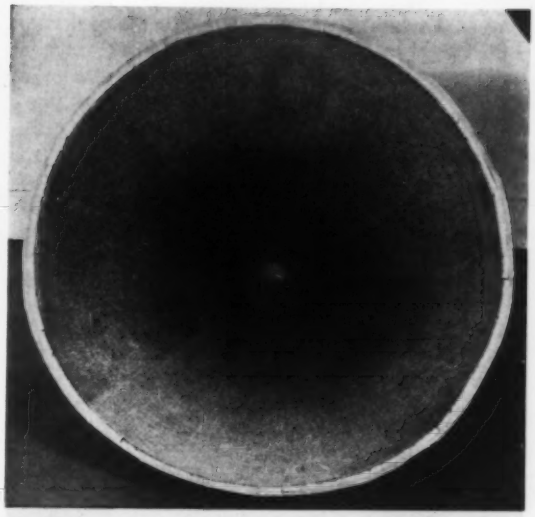


Fig. 13—Contoured shape formed with segments of honeycomb core. This method is suitable for forming thick sections or sections with sharp angles. Segments are cut to shape, fitted in a mold, and bonded

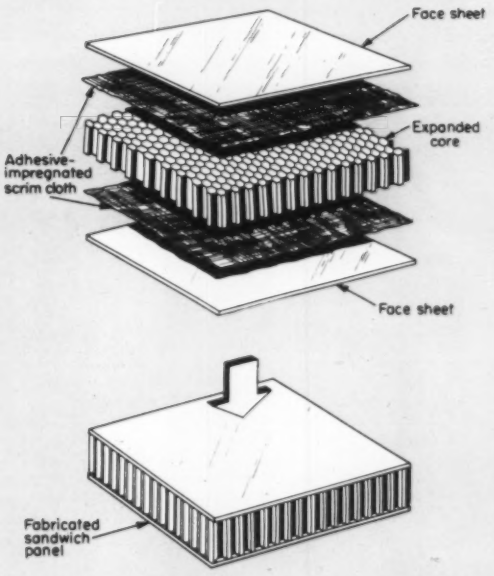


Fig. 14—Bonding of facing to expanded honeycomb-core. Impregnated scrim cloth carries enough adhesive to deposit the required amount on core and skins

strength is required, envelops a contoured-honeycomb core.

Crushing, although not widely used, is also a method for contouring metallic-honeycomb cores. In some instances, crushing is considered to increase structural strength of the piece, while in others it is thought to have a weakening effect. Crushing has been used for forming the core of a honeycomb sandwich for the trailing edge of an aircraft stabilizer. In forming the core for this panel, one machine-cutting operation is saved by crushing the core edge. Structural properties tested in this case indicated no detrimental effects.

Sanding and grinding are usually performed on expanded cores for final fitting to templates. Both are manual operations used for very low production rates or for prototype panels where the expense of constructing dies or jigs is prohibitive as, for example, in the construction of one-of-a-kind, light-weight automobile bodies where smooth surfaces are necessary for good appearance and low air resistance. Sanding and grinding with a pin router are highly effective for volume production of fiberglass-honeycomb shapes.

Joining and Interconnecting Cores

Joining or interconnecting two or more small pieces of core to form one large piece is a technique used when it is physically or economically impossible to form a contoured shape by any other method. Such joining is also feasible when a damaged section of a large core must be replaced, or when the required core is not readily obtainable in sizes needed. Sometimes, too, stress conditions vary across the face of a finished panel, and it may be desirable to have a different core alignment or combinations of different cell sizes to withstand the particular conditions of loading.

Butt Joints: Butting and bonding the edges of two pieces of core is the simplest method of joining. This is the method used when minimum bending strength is required in the region of the joints. In fact, bonding adhesive is sometimes allowed to fill not only the joint but cells adjacent to the joint as well. Where greater strength is required, a zig-zag butt joint is used. Mating edges are cut with a special

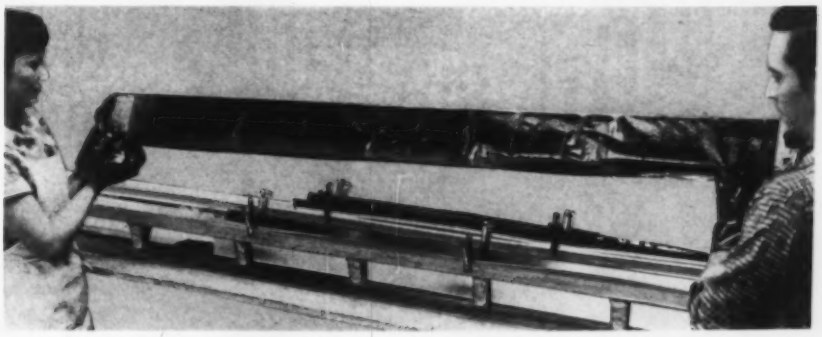


Fig. 15 — Platens for applying heat and pressure simultaneously to flat panels to bond skins and core

steel-rule die (which leaves a zig-zag edge), are butted, and bonded.

Interlocked Joints: Interlocking the core cells provides an even stronger joint. An interlocked joint is formed by overlapping two core edges and forcing one down into the other. With glass-plastic core, interlocking is accomplished by pounding one piece into the other with a rubber mallet. The interlocked cores may then be bonded with a resin, depending on structural requirements.

▶ Skin Attachment

Skins can be attached to cores in a number of ways, depending on core and facing materials and strength requirements of the particular application.

Bonding: The most common means of attachment is with a bonding resin that is heat-cured in forming the finished panel. For glass-plastic and paper, bonding resins are usually of the modified phenolic or polyester type, while for metallic cores, they are generally modified phenolics, epoxies, or combinations of these with a number of other basic resins. Some of the newer metallic-core materials, such as stainless steel, are brazed and spot-welded to skin metals. These techniques form extremely high-strength bonds but are expensive and difficult.

Bonding resins are usually applied to both the honeycomb core and facing. A common technique, used to assure both an even distribution of bonding material and a tough joint, is to impregnate a sheet of thin glass-cloth material (called scrim cloth) with the resin and place it between the core and skin, Fig. 14. The scrim cloth carries enough bonding material, in the form of a dry but uncured resin, to deposit the required amount on both core and skin.

Curing: The parts, assembled with the impregnated scrim cloth between core and skin, may then be cured at either room temperature or elevated temperature while held together under pressure. Room temperature curing sometimes takes days or even weeks, while oven or heat curing can be completed in a matter of minutes. Type of cure depends on the kind of adhesive or bonding agent used.

Flat panels can be heat cured simply by using heated platens which also apply pressure simultaneously to skin surfaces, Fig. 15. However, if

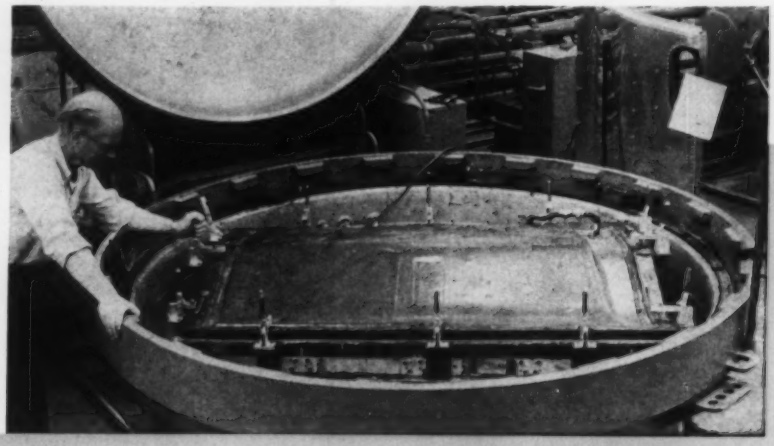


Fig. 16—Method of heat-curing simple-contoured panels. The autoclave is pressurized and the mold within which the panel is placed is heated with steam or oil. Although this is the simplest method for curing contoured panels, it is feasible only if a number of identical panels are produced

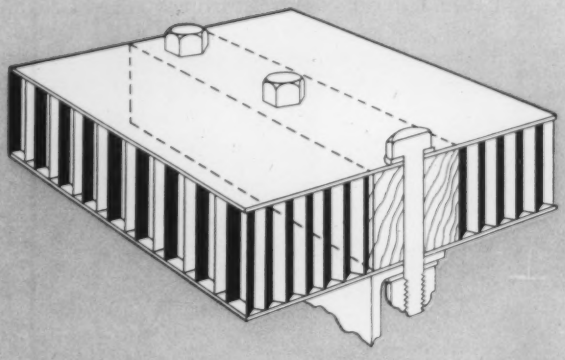


Fig. 17—Blocks of wood or plastic bonded within the sandwich panel for strengthening fastener areas. These members carry highly concentrated loads created by fasteners

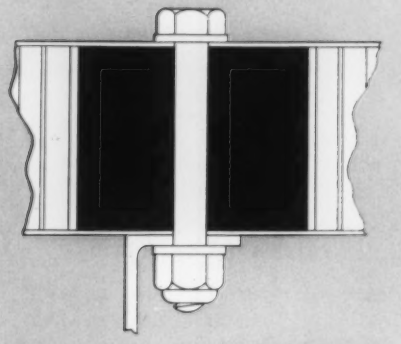


Fig. 18—Plastic block "poured" into a panel section from which the core is removed. Block distributes fastener loads and prevents skin puncture

panels have a contour which makes the use of platens difficult, two other techniques are available. If panel contours are not too complicated, it is often economical to construct a heated mold, Fig. 16. This is the simplest method for bonding contoured panels, but can be justified only if several identical pieces are to be produced.

Facing for panels of more unusual contour can be held in place during bonding with inflated flexible bags. Panels and bags are placed together in an oven where the bags are filled with heated air or steam. The bags hold the facing and core together with the necessary pressure while the adhesive is cured. Typical pressures for this type of bonding may vary from 5 to 200 psig. Temperatures range from 250 to 400 F in heat-curing ovens, so it is necessary to pay special attention to related materials which may be damaged or deteriorated by curing.

Fasteners

Although honeycomb-sandwich panels are strong and rigid, they are susceptible to damage from loads at concentrated points. For this reason it is difficult, if not impossible, to fasten panels with conventional rivets or screws unless the internal core is sufficiently strengthened in the area to be fastened.

Two basic methods are used for strengthening the fastener area. Blocks of solid material, into which threaded fasteners or fastener inserts are screwed, may be bonded in the core, or spacer inserts used.

Strips, or blocks of wood or plastic, are embedded in the core before the sandwich is fabricated, Fig. 17. Holes are then drilled at proper locations for fasteners. Sometimes it is advantageous to use fastener inserts as a first step. An alternate technique is to "pour" a plastic block into the panel after the skin has been bonded on, Fig. 18. A hole is drilled into the panel and a certain amount of core material is removed. A liquid, uncured plastic, usually an epoxy, is forced into the hole and a fastener inserted.

Spacer inserts are spool-like devices that pass entirely through the panel and prevent the fastener from crushing skin or core, Fig. 19. Fasteners may attach directly to the spacer or pass through it.

Edge Close-Out: Edge close-out, Fig. 20, is a special variation of fastening and is most important when fasteners must be placed at the panel edge. Close-outs, usually in the form of blocks of wood or plastic, are bonded within the facing between the edge of the panel and the core. These blocks may be supported by one or two-piece channels bonded to the exterior of the panel for extra strength. The one-piece channel, Fig. 20*a*, is generally more difficult to bond to the panel, since variations in panel thickness or in channel dimensions make a good bond impossible. Bonding of a two-piece channel, Fig. 20*b*, is considerably simpler since there is enough allowable movement between the two pieces before bonding to the panel to assure sufficient adhesion.

Some edge close-out techniques require the channel to be bonded within the sandwich, Fig. 20c. From the standpoint of mass production or involved fabrication, it is usually more economical to have such close-out channels added after the panel is completely fabricated, rather than incorporate it as an integral part of the bonded panel.

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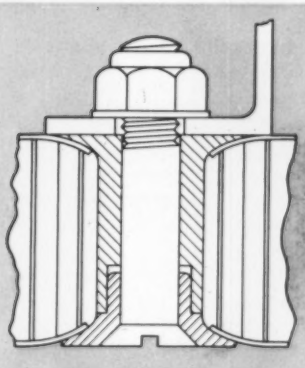

Fig. 19 — Spacer inserts placed in holes drilled through finished panels. These spool-like devices permit tight gripping but prevent fasteners from crushing the panel

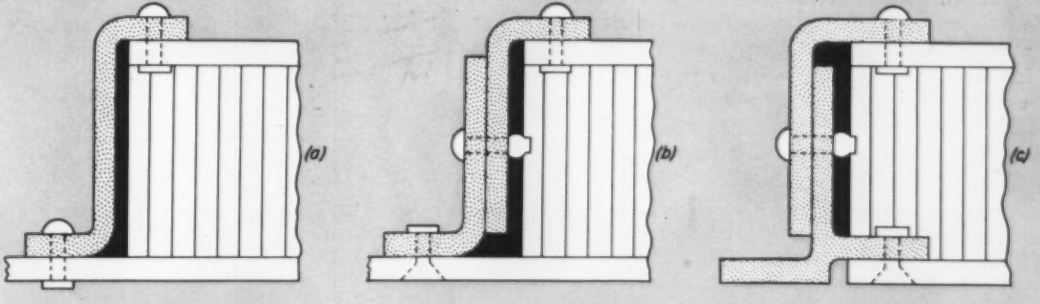

Fig. 20—Edge close-out fastening. This special variation of fastening is most important when fasteners must be located at the panel edge. A one-piece channel fastener, *a*, is difficult to bond since variations in panel thicknesses make a good bond impossible. A two-piece channel fastener, *b*, is simpler to apply and more effective than *a*. Adjustability of two pieces allows sufficient movement to assure good adhesion. Edge close-outs with one channel member bonded within the panel, *c*. It is more economical to add such channels after panel fabrication

Motion Characteristics of

SLIDER-CRANK LINKAGES

By **ERWIN P. POLLITT,** Senior Research Engineer
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LINKAGES containing a rack and a meshing pinion have advantages where rotary oscillations with large amplitude must be produced. For example, the mechanism of Fig. 1 can be used for this purpose. Principal components are a slider crank, a pinion, and a rack attached to the slide.

In an alternate arrangement, the rack is directly attached to the driving crank pin and is held in engagement with the pinion by a spring or by a guide pivoting about the pinion shaft, Fig. 2. This linkage, which has a smaller number of components than that shown in Fig. 1, is known as the "inverted slider-crank mechanism." It is quite frequently employed in machinery and, in combination with an overrunning clutch, it finds use in feeders for punch presses where large feed strokes are necessary. Other applications are found in machine tools and automatic machines.

For producing large oscillations, the inverted slider-crank has an advantage over the slider-crank mechanism of Fig. 1. This is because the pivoted guide for the rack can be more easily incorporated into many designs than the fixed guide of the conventional slider-crank since the pinion shaft itself can be used as the supporting member of the guide.

Velocity Characteristics: Velocities and accelerations of mechanisms containing racks and pinions can be determined by conventional means, and well known graphical methods can be applied. Plotted in Fig. 3*a* and 3*b* are velocity-time diagrams of the mechanisms of Fig. 1 and 2, respectively. These diagrams apply to linkages of similar proportions. Crank circles and pinion pitch circles have equal diameters and connecting-rod length equals the average distance between crank pin and mesh point of rack.

Comparison between these velocity diagrams, Fig. 3*a* and *b*, and of acceleration diagrams (not shown) indicates the following main differences in linkage characteristics:

1. Since the pitch-line velocity of the pinion in the inverted slider crank mechanism, Fig. 2, is equal to the projection of the crank-pin velocity vector on the rack pitch line (Fig. 12), the maximum ratio between these velocities can never be larger than one. In the slider-crank mechanism of Fig. 1, on the other hand, the maximum ratio is always larger than one.

2. With the assumed linkage proportions, maximum acceleration of the pinion (uniform crank speed), which occurs at the reversal point where the crank pin is closest to the pinion, is larger for

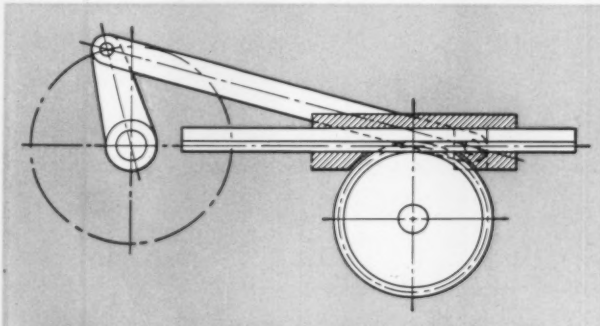
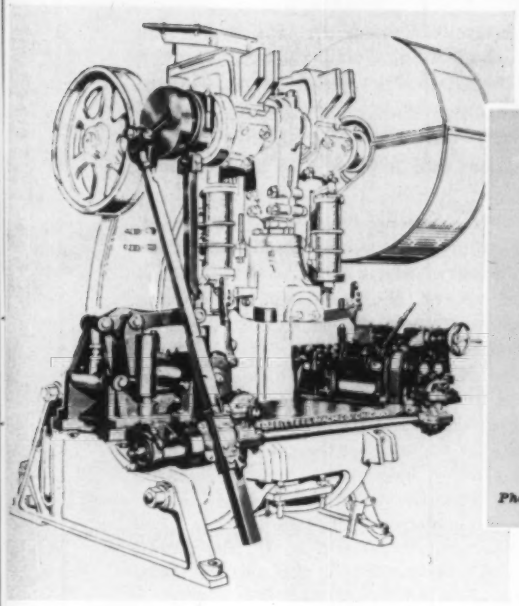


Fig. 1—Slider-crank linkage. Translating rack engages pinion, generating large-amplitude oscillatory motion.



Linkages containing a rack and meshing pinion can be employed with advantage where rotary oscillations with large amplitude must be produced. If the rack is directly attached to the driving crank pin and held in engagement with the pinion by a guide pivoting about the pinion shaft, the device is known as the inverted slider-crank mechanism. In this press installation, the slider-crank provides smooth harmonic motion, with gradual acceleration and deceleration of the feed rolls.

Photo courtesy F. J. Littell Machine Co.

the mechanism of Fig. 2 than in the comparable slider-crank mechanism of Fig. 1. Also, the maximum angular acceleration of the rack is larger than that of the connecting rod of the mechanism of Fig. 1. However, the drawback of such larger accelerations will, in most cases, be outweighed by the advantages of design simplicity.

Displacement Characteristics: The time-displacement diagram of the linkage of Fig. 2 can be obtained by direct integration of the time-velocity diagram. Alternatively, graphical methods can be employed, offering a time saving over the analytical method. One such graphical method is illustrated in Fig. 4.

As a starting point, crank position B is selected where the rotation of the pinion is reversed. At the corresponding position of the rack, its mesh point with the pinion pitch-circle PC lies at E. As the crank pin moves from B to B_1, B_2, etc., the rack moves to positions B_1E_1, B_2E_2, etc.

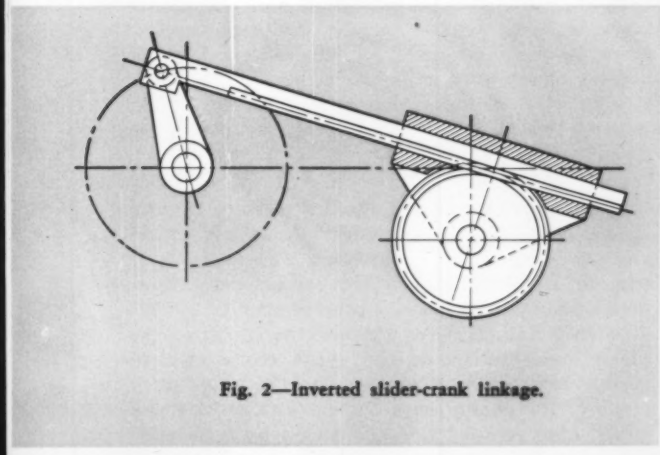


Fig. 2—Inverted slider-crank linkage.

Such motions of the rack can be considered to be the resultant of two motions: 1. A rolling motion of the rack about the pinion pitch circle. 2. A subsequent translation of the rack along its own pitch line. Only the latter motion of the rack causes rotation of the pinion. After its magnitude is determined, the angular displacement of the pinion can be found.

When the rack is assumed to be detached from the crank pin and rolled around the pinion pitch circle, rack point B describes the involute i_b, Fig. 4. The involute intersects the rack pitch-line positions corresponding to crank-pin positions $B_1, B_2, \ldots, B_n$ at the points $B', B'', \ldots, B^n$. Distances B_1B', B_2B'' then represent the translatory displacements which the rack must perform in order to bring the crank pin back to the crank circle. When these distances are divided by the pitch-line radius, the angular displacement of the pinion for the crank positions $B_1, B_2, \ldots, B_n$ is found. Only one involute need be drawn, which permits quick execution of the method.

Another method is the following: Motion of the rack is thought of as rotation of the rack about the pinion center, and subsequent translation in the direction of its pitch line. The rack is again considered as detached from the crank but locked to the pinion. Together with the pinion, the rack is rotated about the center of the pinion shaft, Fig. 5, and rotation is stopped at any arbitrarily chosen point B_1' on the circle with radius BO and center O. The rack is then translated in the direction of its own pitch line until point B_1' reaches the point B_1 of intersection of the rack pitch line

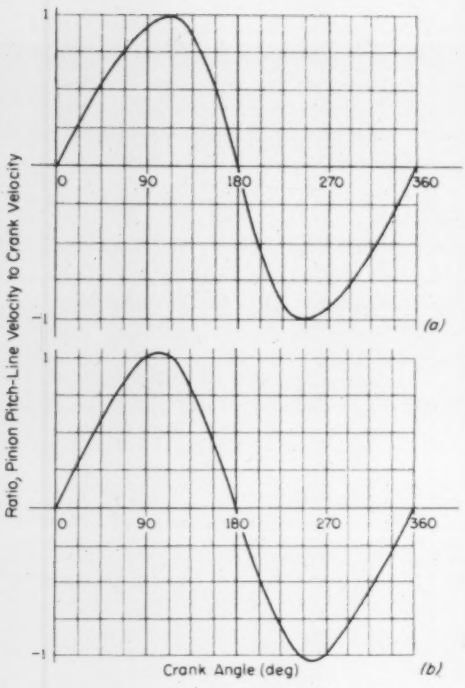


Fig. 3—Comparison of velocity characteristics of conventional slider-crank linkage, *a*, and inverted slider-crank linkage, *b*.

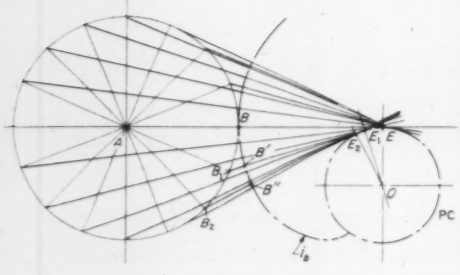


Fig. 4—Graphical determination of inverted slider-crank displacement characteristics.

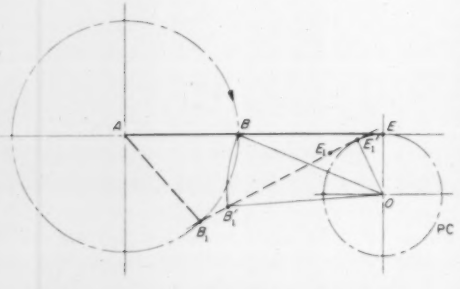


Fig. 5—Alternate method for determining displacement characteristics.

with the crank circle. During the translation, the original point E of tangency of rack and pinion, which during rotation has moved to E_1', moves to E_1. The length of the arc EE_1' plus the distance E_1E_1' represents the length of the arc through which the pinion pitch line has traveled.

Eccentric Pinion: Motion characteristics of the inverted slider crank can easily be modified by arranging the pinion eccentrically on its shaft, Fig. 6. Graphical analysis of the displacement of the pinion is carried out by methods similar to those described in forgoing sections.

In Fig. 6, the center of the pinion shaft is designated O, and for crank position AB, the position of the center of the pitch circle PC is assumed at D. Eccentricity of the pinion is OD. Again the rack is assumed to be detached from the crank, and the pinion, with the rack locked to it, is rotated through an arbitrarily chosen angle α. The pinion center then moves from D to D', the pinion pitch circle from position PC to position PC', and the rack points B and E to B' and E'.

The actual rack position corresponding to this rotation of the pinion is found by rolling the rack on pitch circle PC' until the involute i_b described by rack point B' intersects the crank circle at point B_1. The new mesh point of rack and pinion is then E_1. Rolling of the rack does not cause the pinion to rotate; consequently, angle DOD' is the angle of rotation of the pinion shaft corresponding to rotation BAB_1' of the crank.

The next crank point is determined in the same manner, using the new position B_1E_1 of the rack, and PC' of the pinion pitch circle as the starting point for the procedure. The involute must be drawn for every selected pinion position because, unlike the case of the concentric pinion, the involute to the pinion pitch circle continuously changes its position as the position of the circle keeps changing.

If the pinion has a noncircular pitch line, the procedure is the same as that for the eccentric pinion, except that the curves described by the points of the rack rolling on the pinion are different from an involute of a circle.

When the pinion lies outside the crank circle, inspection of the linkage shows that the maximum velocity ratio of pinion to crank occurs when the rack is tangent to both the crank circle and the pinion pitch circle. Furthermore, the pitch-line velocity of the pinion equals the crank pin velocity, which result in the large velocity ratio given by this linkage form.

Modified Slider Crank: Besides producing large oscillations, the inverted slider-crank mechanism has other interesting properties. For example, it can be modified to produce complete rotations with a nonuniform velocity pattern, similar to that of a drag link. For this purpose the center of the pinion must lie inside the crank circle and, to permit rack action at every point, the whole pitch circle of the pinion must also lie within the crank circle. It is recalled that the pinion must lie com-

pletely outside of the crank circle in a linkage for producing oscillatory motions. No working mechanism is possible if the pinion pitch circle intersects the crank-pin circle.

Several cases of this modification of the inverted slider crank can be distinguished:

Case 1. The center of the crank circle lies within the pinion pitch circle, Fig. 7.

Case 2. The center of the crank circle lies on the pinion pitch circle, Fig. 8.

Case 3. The center of the crank circle lies outside of the pinion pitch circle, Fig. 9.

The design of these linkages is indicated in Fig. 7*a*, 8*a*, and 9*a*. A special variety of each case is a linkage where the pinion pitch circle is tangent to the crank circle, Fig. 7*b*, 8*b*, and 9*b*. Velocity diagrams for significant link configurations are plotted in Fig. 7*c*, 8*c*, and 9*c*. Relations between crank angle and the ratio of pinion pitch-line velocity to crank-pin velocity are shown in Fig. 7*d*, 8*d*, and 9*d*.

In Fig. 7 (Case 1), inspection shows that the direction of rotation of the pinion is the same as that of the crank during all phases of the cycle. The velocity diagram, Fig. 7*c*, shows that the projection V_E of the crank velocity vector V_B on the rack pitch line, which equals the mesh-point or pinion pitch-line velocity, lies to the same side of the crank pin B for all link configurations. Also, the pinion pitch-line velocity is always different from zero, and the velocity ratio is always positive.

In Fig. 8 (Case 2), direction of rotation of the

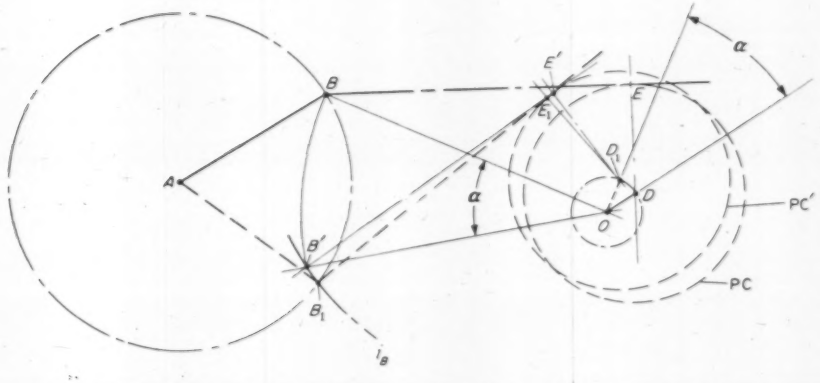


Fig. 6 — Slider-crank with eccentrically mounted pinion.

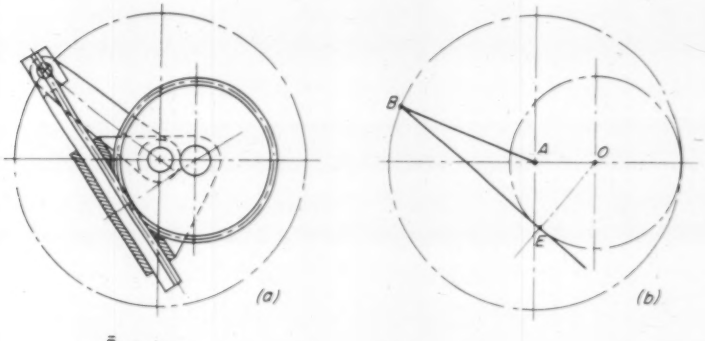
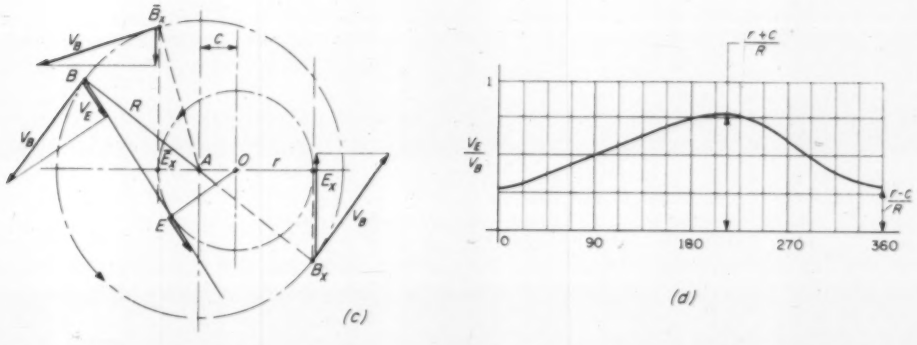


Fig. 7 — Inverted slider-crank linkage with pinion center inside crank circle. Center of crank circle lies within pinion pitch circle.



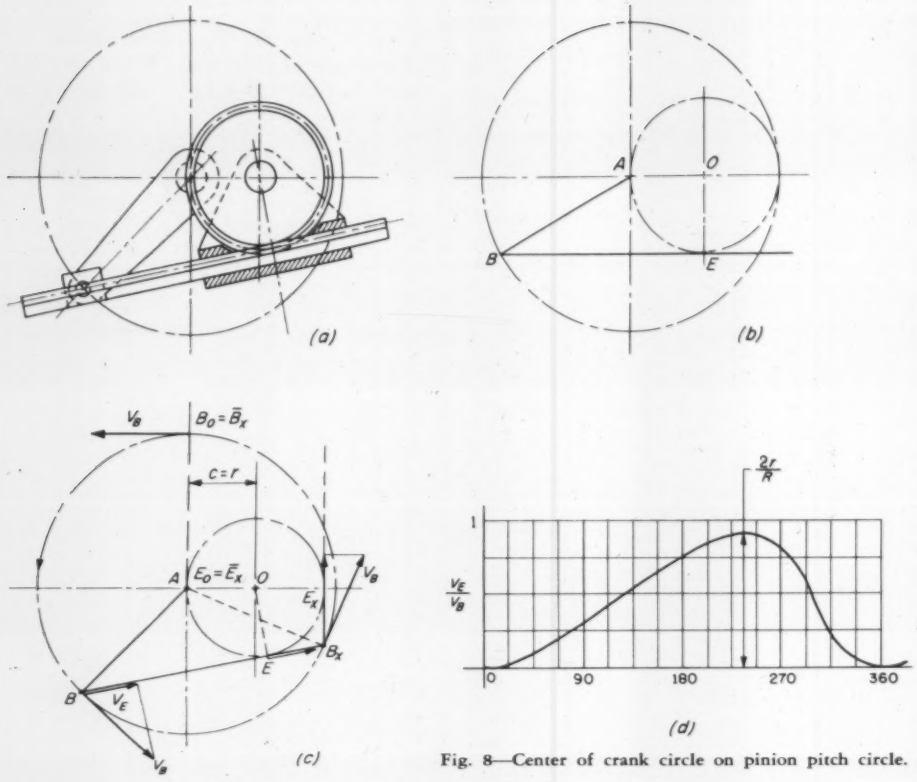


Fig. 8—Center of crank circle on pinion pitch circle.

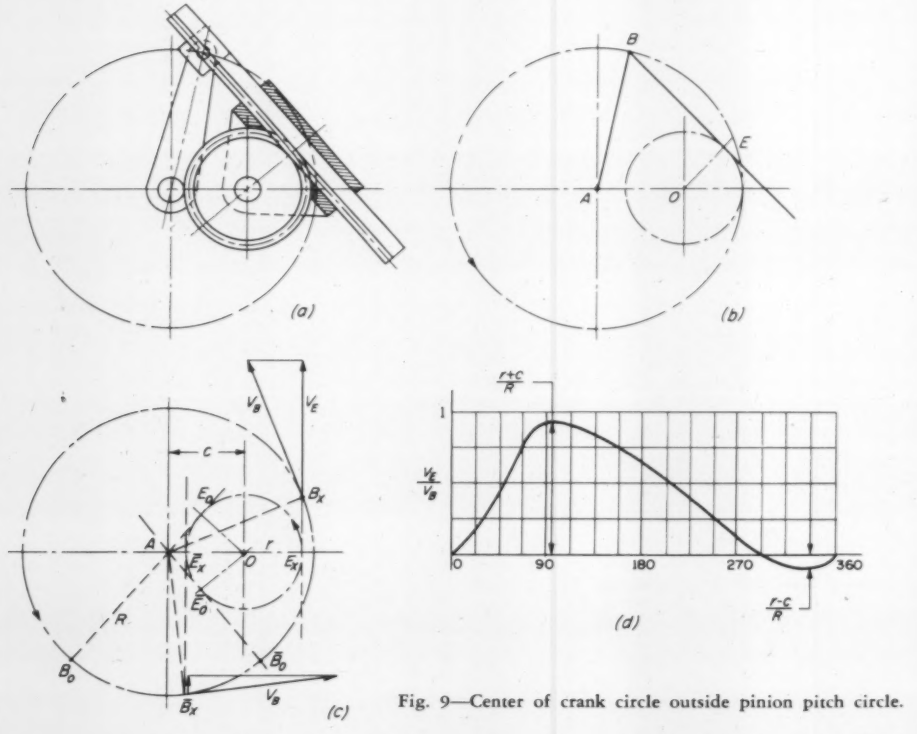


Fig. 9—Center of crank circle outside pinion pitch circle.

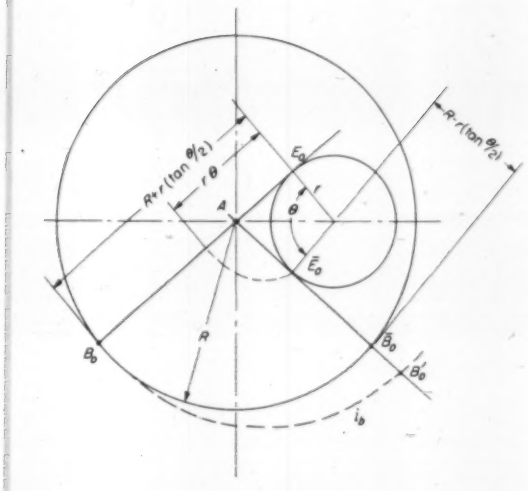


Fig. 10—Graphical determination of displacement for drag-link form of inverted slider crank.

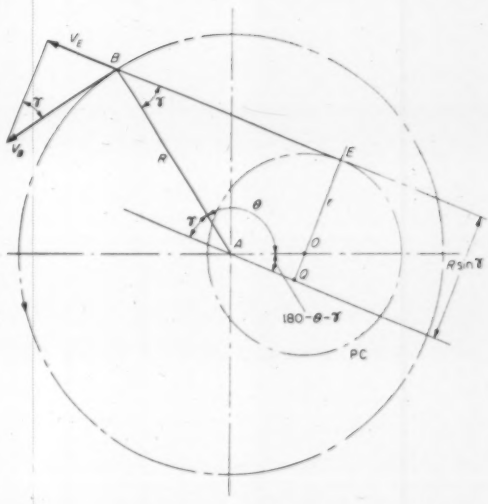


Fig. 11—Kinematic determination of maximum ratio of pitch-line velocity to crank-pin velocity. Pinion is concentrically mounted inside crank circle.

pinion is also the same as that of the crank for all link configurations, as illustrated in the velocity diagram, Fig. 8*c*. Reasons are the same as for the preceding case. The velocity ratio, however, becomes zero for crank position B_o, where the crank coincides with the rack pitch line, and mesh point E_o coincides with the center of the crank circle.

In Fig. 9 (Case 3), there are two rack positions, B_oE_o and $\overline{B}_o\overline{E}_o$ (Fig. 9*c*), where the rack pitch line coincides with the corresponding crank radii, and the pitch-line velocity of the pinion becomes zero. For crank positions between these two positions, like $\overline{B}_z$, the projection of the crank-pin velocity vector on the rack pitch line lies on the opposite side of the crank pin than it does for the remaining crank positions. Consequently, the direction of rotation of the pinion becomes reversed for these crank positions.

Drag-Link Forms: The previously described methods for determining the displacement of the inverted slider-crank pinion can also be applied to linkages of the drag-link type. In the case of a linkage of the type shown in Fig. 9, total displacements in both directions of rotation occurring during each cycle can be found as illustrated in Fig. 10. Starting with the rack position B_oE_o, where the direction of pinion rotation is reversed, the rack is rolled on the pinion pitch circle until its position coincides with the rack position $\overline{B}_o\overline{E}_o$ at the second reversal point of the pinion rotation. The involute i_b, described by B_o while the rack is being rolled, intersects $\overline{B}_o\overline{E}_o$ at B_o', and distance $\overline{B}_oB_o'$ is equal to the length of the arc through which the pinion pitch circle must travel in order to bring B_o' into coincidence with $\overline{B}_o$. The corresponding angle of rotation $\Delta\theta$ of the pinion (clockwise) is

$$\Delta\theta = 2\left[\tan\left(\frac{\theta}{2}\right) - \frac{\theta}{2}\right] \qquad (1)$$

Counterclockwise, pinion rotation during the cycle is

$$\Delta\theta = 2\pi + 2\left[\tan\left(\frac{\theta}{2}\right) - \frac{\theta}{2}\right] \qquad (2)$$

The drag-link type of linkages, Fig. 7 and 8, can be employed where quick-return motions are required by using the pinion to drive a slider-crank mechanism or an inverted slider-crank mechanism. A linkage with the proportions of Fig. 8 is particularly noteworthy in that it provides an instantaneous dwell once during every revolution of the pinion. A linkage with the proportions of Fig. 9 can be used in combination with an overrunning clutch in mechanisms where an intermittent motion with a short or a long dwell is required, provided that the finite accelerations at the beginning and end of the dwell are not objectionable.

Extreme Velocity Ratios: With concentrically mounted pinions, the configurations in which extreme values of the ratio of the pitch-line velocity of pinion and rack to the crank-pin velocity occur can be determined by kinematical analysis. From the diagrams, Fig. 11 and 12, the velocity of the meshpoint E is

$$V_E = V_B \sin\gamma \qquad (3)$$

where V_B is the velocity of the crank pin B, and γ is the angle between the crank and the rack pitch line.

A relation between crank angle θ and angle γ can be derived from the triangle AOQ, where AQ

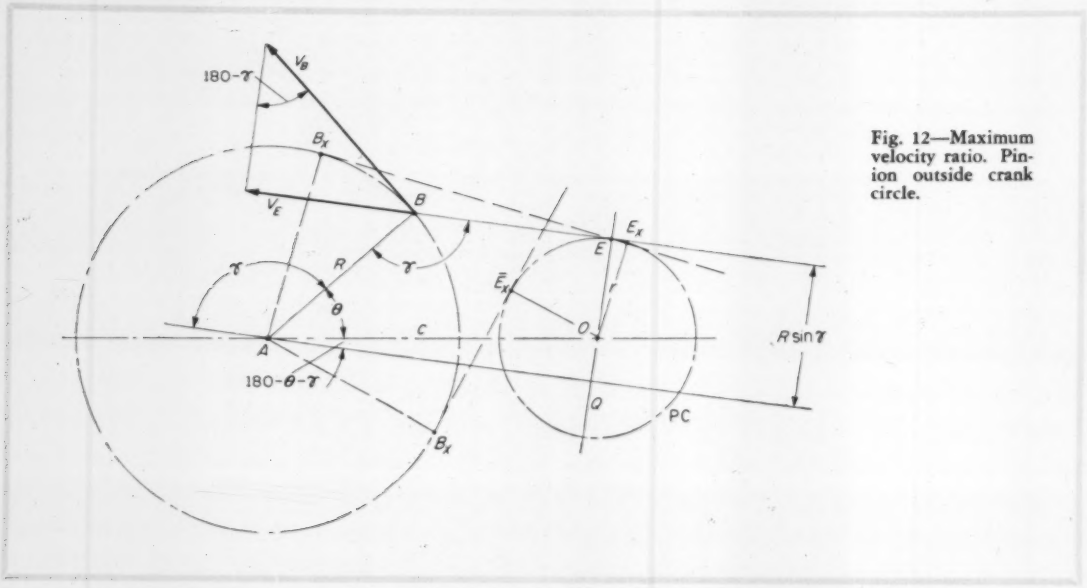


Fig. 12—Maximum velocity ratio. Pinion outside crank circle.

is a line parallel to the rack pitch line through the crank center, while OQ lies on the normal to the rack pitch line through the pinion center. From this triangle,

$$c \sin (\gamma + \theta) = R \sin \gamma - r$$

$$c(\sin \gamma \cos \theta + \cos \gamma \sin \theta) = R \sin \gamma - r \quad (4)$$

Substituting z for $\sin \gamma$ and regrouping terms,

$$cz \cos \theta + c\sqrt{1 - z^2} \sin \theta - Rz + r = 0 \quad (5)$$

Differentiating this equation with respect to z and θ yields

$$\frac{dz}{d\theta} = \frac{\sqrt{1 - z^2}\,(\cos \theta \sqrt{1 - z^2} - z \sin \theta}{\cos \theta \sqrt{1 - z^2} - z \sin \theta - \dfrac{R}{c}\sqrt{1 - z^2}} \quad (6)$$

For extreme values of z, the derivative must become zero. The numerator equals zero when one of its factors is zero, or

$$\sqrt{1 - z^2}\,(\cos \theta \sqrt{1 - z^2} - z \sin \theta) = 0 \quad (7)$$

In the linkages of Fig. 7*c*, 8*c*, and 9*c*, angle γ is always different from zero. Consequently, only the second factor can become zero for linkages of this kind. This occurs if

$$\sin \gamma = \pm \cos \theta \quad (8)$$

$$\gamma = \pm \left(\frac{\pi}{2} \pm \theta \right) \quad (9)$$

Substitution of associated values of $\sin \gamma$ and $\cos \gamma$ in Equation 5 yields

$$\pm c \sin^2 \theta \pm c \cos^2 \theta = R \cos \theta - r$$

The two solutions of this equation yielding values of $\cos \theta$ not larger than unity are

$$\cos \theta_{1,2} = \frac{r \pm c}{R} \quad (10)$$

These crank angles occur at crank positions where the rack pitch line is perpendicular to the line AO through the centers of crank and pinion.

In the case of the linkage in Fig. 8*c*, where center distance $c = r$,

$$\cos \theta_{1,2} = \frac{2r}{R}\ ,\ 0 \quad (11)$$

In the case of Fig. 7*b*, 8*b*, and 9*b*, where the pinion pitch circle is tangent to the crank circle, center distance $c = R - r$, and

$$\cos \theta_{1,2} = 1\ ,\ \left(\frac{2r}{R} - 1 \right) \quad (12)$$

For the inverted slider-crank mechanism, Fig. 12, substitution of $c > (R + r)$ in Equation 10 does not yield real values for the crank angle. However, by setting the first factor in Equation 7 equal to zero, the roots, $\sin \gamma = \pm 1$, are obtained. This determines the link configurations for the extreme ratio of mesh point to crank velocity for this kind of linkage. Such results are in agreement with the results of a visual inspection. The link configurations in which the extreme velocity ratios occur are marked B_x, E_x, $\bar{B}_x$, $\bar{E}_x$ in Fig. 7*c*, 8*c*, 9*c*, and 12.

It can easily be proved that the rack pitch line is perpendicular to the collineation axis for those configurations of the discussed linkages where the extreme ratio of mesh point velocity to crank pin velocity occurs. In this respect these linkages display the same properties as the common four bar linkages.

A Mechanisms Conference Paper

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Tables and equations for a simplified approach to

SPUR-GEAR DESIGN

. . . a method for rapidly finding approximate gear dimensions from either wear or bending limits

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A large number of variables, many of them related, must be specified in the design of a set of spur gears for power transmission. Because of the interdependence of many of the variables, an indirect method for determining gear specifications is often used. That is, certain logical values are assumed for a number of the variables required in gear design, and values for the remaining variables are calculated. These calculated quantities are then used to determine and check the initially assumed values.

Nearly all gear dimensions are specified as a function of diametral pitch. As a result, this variable is the one most often solved for first in gear calculations. Since cost, weight, and volume of a gear are inversely proportional to diametral pitch, it is important that the largest diametral pitch consistent with power requirements be obtained.

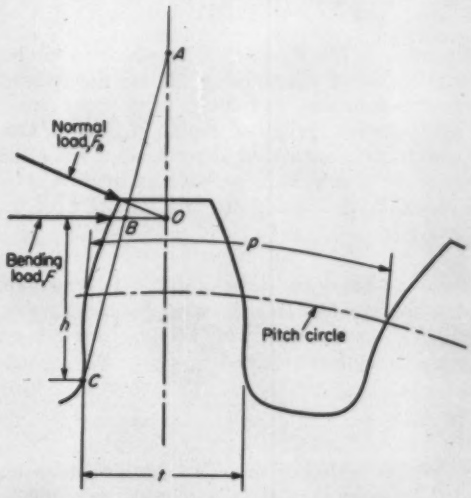

Fig. 1—Basic relationships for analysis of bending load on gear tooth. Distances *AB* and *BC* are equal. Lewis form factor $y = t^2/6ph$

Nomenclature

C = Center distance, in.
d = Pitch diameter of pinion, in.
f = Face width of gear, in.
F = Torque-producing load, lb
k = Product of face width and diametral pitch $= fP$
K = Surface-fatigue load-stress factor
K' = Gear-tooth fillet stress-concentration factor
N_G = Number of teeth on gear
N_P = Number of teeth on pinion
N_P' = Number of teeth on pinion having bending strength equal to wear strength
p = Circular pitch, in.
P = Diametral pitch
Q = Ratio factor $= 2m_G/(1 + m_G)$
s = Nominal bending stress, psi
S = Endurance limit in bending, psi
T = Torque on gear shaft, lb-in.
m_G = Velocity ratio (input speed/output speed) $= N_G/N_P$
y = Lewis form factor
ϕ = Pressure angle of gear teeth, deg

Bending Strength: In recent literature,[1,2,3] use of the Lewis formula to determine a first approximation of the diametral pitch for a set of power-transmitting gears has frequently been suggested. This equation relates approximate bending stress at the root of a spur gear tooth in terms of tooth dimensions and torque-producing load transmitted by the tooth, Fig. 1:

$$F = ypfs \tag{1}$$

This equation may be modified to give diametral pitch P in terms of torque on the pinion shaft, bending-fatigue strength of the pinion material, and number of teeth on the pinion by introducing the relationships,

$$F = \frac{2TP}{N_P}$$

$$p = \frac{\pi}{P}$$

$$f = \frac{k}{P}$$

$$s = \frac{S}{K'}$$

Based on an evaluation of practical face-width proportions and stress-concentration conditions, it will be assumed here that $k = 11$ and $K' = 2$. Thus, by substitution in Equation 1,

$$P = \left(\frac{8.7 N_P y S}{T} \right)^{1/3} \tag{2}$$

After diametral pitch P has been solved with Equation 2, or its equivalent, standard proportions of the gears can be determined and the value of dynamic load[4] calculated.

The dynamic-load value is needed for a more accurate calculation of induced bending stress in the gear teeth. More important, the dynamic load represents the force that the gear tooth profiles must be able to transmit if failure from surface fatigue is to be avoided.

Wear Strength: Buckingham[5] has derived a formula relating surface-fatigue load-stress factor K for the gear teeth in terms of gear load, dimensions, and materials properties, Fig. 2:

$$F = dfQK \tag{3}$$

This equation may be modified to give diametral pitch P in terms of torque on the pinion shaft, load-stress factor, velocity ratio, and number of teeth on the pinion by introducing the relationships,

$$F = \frac{2TP}{N_P}$$

$$d = \frac{N_P}{P}$$

$$f = \frac{k}{P} = \frac{11}{P}$$

Substituting in Equation 3,

$$P = \left(\frac{5.5 N_P^2 QK}{T} \right)^{1/3} \tag{4}$$

Equation 4, like Equation 2, can be used to obtain a trial value of diametral pitch for determination of gear proportions and for a more exact analysis of gear stresses. Whether Equation 2 or 4 should be used for this calculation depends upon the number of teeth in the pinion, as well as quality of gear manufacture, gear materials, and type of heat treatment.

Balanced-Strength Relationship: If Equations 2 and 4 are equated, an expression for the number of teeth, N_P', on a pinion with bending strength equal to wear strength is obtained:

$$N_P' = 1.57 \frac{yS}{QK} \tag{5}$$

Any pinion with less than N_P' teeth is more likely to fail in wear than from a repeated bending load.

Design Approach: Table 1 summarizes assumptions and results of a series of calculations which were made to determine the value of N_P' for gears of different tooth forms, materials, and heat treat-

[1]References are tabulated at end of article.

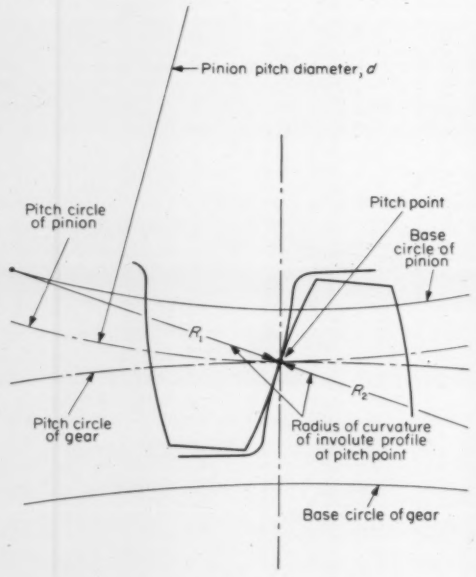

Fig. 2—Basic relationships for analysis of wear load on gear-tooth surface. Ratio factor $Q = 2R_1/(R_1 + R_2)$ or, as defined in Nomenclature, $2\,m_G/(1 + m_G)$. Buckingham load-stress factor K is a function of the pressure angle and of the elasticity and the surface endurance limits of the gear materials

Table 1—Typical Gear Specifications for Equal Strength in Wear and Bending

Specification	Commercial	Accurate	Precision
Tooth form	14½-deg full depth	14½-deg full depth	14½-deg full depth
Pinion material ...	Steel, 150 Bhn	Steel, 320 Bhn	Steel, 400 Bhn
Gear material ...	Cast iron	Steel, 240 Bhn	Steel, 400 Bhn
m_G	3	3	3
N_P'	33	68	47
Tooth form	14½-deg full depth	20-deg full depth	20-deg full depth
Pinion material ...	Steel, 150 Bhn	Steel, 320 Bhn	Steel, 400 Bhn
Gear material ...	Steel, 150 Bhn	Steel, 240 Bhn	Steel, 400 Bhn
m_G	3	3	3
N_P'	122	62	39
Tooth form	20-deg full depth	20-deg stub	20-deg stub
Pinion material ...	Steel, 150 Bhn	Steel, 320 Bhn	Steel, 400 Bhn
Gear material ...	Steel, 150 Bhn	Steel, 240 Bhn	Steel, 400 Bhn
m_G	3	3	3
N_P'	98	76	48

Table 2—Gear Design Data

1. Lewis Form Factor, y

Number of teeth	y 14½-deg full depth	y 20-deg full depth	y 20-deg stub
10	0.055	0.064	0.088
28	.100	.112	.137
100	.117	.142	.161
150	0.119	0.146	0.165

2. Endurance Limit in Bending, S

Material	Hardness (Bhn)	S (psi)	Gear Class
Cast iron	...	12,000	Commercial
Steel	150	35,000	Commercial
Steel	240	60,000	Accurate
Steel	320	80,000	Accurate
Steel	400	100,000	Precision

3. Load-Stress Factor, K

Hardness (Bhn)	K $\phi = 14\frac{1}{2}$ deg	K $\phi = 20$ deg	Gear Class
Steel Pinion with Cast Iron Gear			
150	45	62	Commercial
225	100	150	Commercial
300	225	300	Commercial
Steel Gear and Pinion			
300*	30	42	Commercial
550*	120	150	Accurate
800*	260	360	Precision

*Sum of gear and pinion values.

4. Ratio Factor, Q

Velocity Ratio, m_G	Q	Velocity Ratio, m_G	Q
1	1.00	4	1.60
2	1.33	5	1.66
3	1.50	10	1.82

ments. These data show that, in general, Equation 4, the wear equation, should be used for estimating the diametral pitch of gear sets in which the pinion has 33 teeth or less. This will be the case in most gear sets designed for general machine use.

These results reflect the experience of one major gear manufacturer, whose catalog states: "The AGMA horsepower ratings for spur gears which appear on the following pages involve a departure from our previous method of determining ratings. Formerly the spur gear ratings were determined by the use of the tooth beam strength formula only. The new ratings take into consideration the surface durability as well as the beam strength. Usually the surface durability rating is less than the beam strength rating and in some instances, considerably less."

If the diametral pitch of a set of spur gears is to be estimated by means of either Equation 2 or 4, certain values for the variables appearing in these equations must be either specified or assumed. Many

Table 3—Application Factors

1. Duty Factor

Power Source	Duty Factor* Uniform Load	Moderate Shock Load	Heavy Shock Load
Electric motor	1.00	1.25	1.75
Multiple-cylinder engine	1.25	1.50	2.00
Single-cylinder gas engine	1.50	1.75	2.25

*Alter duty factor as follows, according to duration of operation: For 3 hr/day operation, multiply factor by 0.80; for 8 hr/day, multiply by 1.00; for 24 hr/day, multiply by 1.25.

2. Velocity Factor

Gear Class	Pitch-Line Velocity Limit (fpm)	Velocity Factor
Commercial	1300	2.50
Accurate	2700	2.00
Precision	...	1.25

machine design texts, monographs on gears, and gear manufacturers' catalogs contain information that is helpful in assuming these initial values. Representative values from these sources are given in Table 2. This abbreviated form of data is sufficient for initial design calculation of gears specified for general machine service. More complete tables of data will be found helpful in later stages of calculation as the initial specifications of the gears are refined.

For convenience, the many conditions of manufacture and finish of spur gears have been reduced to three general quality classifications:

1. Commercial gears are defined as milled or generated gears made from cast iron or steel and not heat treated.
2. Accurate gears are milled or generated gears made from steel and heat-treated before forming.
3. Precision gears are cut from steel, heat-treated, and generation-grind finished.

Factors of safety and other design factors are most conveniently applied by multiplying input torque by the factor or factors and substituting this product for T in Equations 2 and 4. Table 3 lists typical values of conventional duty factors and also gives average values for pitch-line velocity factors. The latter data should be used only for determination of an initial diametral pitch (Equations 2 and 4). A more refined calculation[4] of dynamic load should be made after gear proportions have been fixed.

Example 1: Two 20-deg full-depth involute gears are to transmit 80 hp at 1800 rpm of the pinion. Power source is an electric motor operating 8 hr per day and the load is moderate shock. Speed ratio $m_G = 1.5$ and gear center distance $C = 7.5$ in. If precision quality gears are to be used, determine their pitch and number of teeth on the gear and pinion.

From Table 3, velocity factor = 1.25 and service factor = 1.25. Torque $T = 1.25(1.25)(63030)(80/1800) = 4375$ lb-in. Ratio factor $Q = 2(1.5)/(1 + 1.5) = 1.2$. From Table 2 for precision gears and $\phi = 20$ deg, load stress factor $K = 360$.

Assume number of pinion teeth $N_P = 30$. From Equation 4,

$$P = \left[\frac{5.5(30)^2(1.2)(360)}{4375} \right]^{1/3} = 7.95$$

Use $P = 8$.

Center distance $C = (N_G + N_P)/(2P) = 7.5$, giving $N_G + N_P = 120$. Also, $Q = N_G/N_P = 1.5$. Thus, $N_P = 32$ and $N_G = 48$.

Example 2: A 20-deg full-depth steel pinion with 18 teeth and a cast-iron gear with 75 teeth are transmitting 50 hp at 1400 rpm of the pinion. Power source is an electric motor operating 8 hr per day. Load is uniform. Determine diametral pitch required in each case where the pinion is heat treated to 150, 225 or 300 Bhn.

From Table 3, velocity factor = 2.5 (commercial gears) and service factor = 1. Torque $T = 1(2.5)(63030)(50/1400) = 5640$ lb-in. Velocity ratio $m_G = 75/18 = 4.17$. Ratio factor $Q = 2(4.17)/(1 + 4.17) = 1.61$.

From Table 2 for 150 Bhn pinion, cast-iron gear, and $\phi = 20$ deg, load stress factor $K = 62$. From Equation 4,

$$P = \left[\frac{5.5(18)^2(1.61)(62)}{5640} \right]^{1/3} = 3.16$$

Use $P = 3$.

For a 225 Bhn pinion, following the same procedure gives $K = 150$ and, from Equation 4, $P = 4.25$ or 4.

Similarly, for a 300 Bhn pinion, $K = 300$ and $P = 5.32$ or 5.

Example 3: Two 20-deg full-depth involute gears are to transmit 85 hp at 300 rpm of the pinion. Electric-motor drive operates 24 hr per day. Load is uniform. Velocity ratio $m_G = 5$. Gear is C-1045 steel untreated and pinion is alloy steel preheat-treated to 240/260 Bhn. Determine diametral pitch of gear set.

From Table 3, velocity factor = 2.0 (accurate gears) and service factor = 1.25. Torque $T = 1.25(2.0)(63030)(85/300) = 44800$ lb-in.

From Table 2, ratio factor $Q = 1.66$ and, also, for accurate gears with $\phi = 20$ deg, load stress factor $K = 150$.

Assume number of pinion teeth $N_P = 30$. From Equation 4,

$$P = \left[\frac{5.5(30)^2(1.66)(150)}{44{,}800} \right]^{1/3} = 3.02$$

Use P = 3.

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2. A. Vallance and V. L. Doughtie—*Design of Machine Elements*, Third Edition, McGraw-Hill Book Co. Inc., New York, 1951.
3. M. F. Spotts—*Design of Machine Elements*, Second Edition, Prentice Hall Inc., New York, 1953.
4. E. Buckingham—*Analytical Mechanics of Gears*, McGraw-Hill Book Co. Inc., New York, 1949, Chapter 20.
5. Reference 4, pp. 528-529.

Tips and Techniques

Tracing Aid

Keeping track of which lines have been transfered to which sheet can be a nuisance when different portions of a drawing are transferred to individual sheets by carbon paper. The use of a different colored pencil in the tracing operation can eliminate the inconvenience of the "draw and peek" technique. All the lines transferred to the same sheet will show on the original drawing in one color. —C. S. DAYTON, *Peabody, Mass.*

Design trends and developments in

High-Temperature Hydraulic Components

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- **Metallurgical factors**
- **Fluids, present and future**
- **Trends in seal design**
- **Actuator materials**
- **Electrical problems**
- **Special-fluid systems**

SEVERAL temperature classes for hydraulic systems attempt to establish reasonable operating ranges to aid in the design and development of equipment for various applications. These classes include three which are generally accepted and widely used:

Class 1: −65 to +160 F.
Class 2: −65 to +275 F.
Class 3: −65 to +400 F.

Proposed classes include several which are used to some extent:

Class 4: 0 to +550 F.
Class 5: 0 to +700 F.
Class 6: 0 to +1000 F.

Application problems tend to complicate component development. For this reason, designs must be realistic and capable of withstanding unpredictable service conditions.

Temperature Effects on Metals: Among the problems involved in extending the operating-temperature range of hydraulic units is the deleterious effect on physical properties of metals. The principal effects of concern to the designer are: Loss of hardness, reduction in strength, creep, accelerated wear and galling, and thermal expansion.

Loss of hardness results in brinelling and permanent deflections of various parts which lead to either rapid wear or to increased leakage. The solution is to utilize materials that retain hardness well beyond the application temperature. However, there are limitations to this concept. It is difficult to find materials which work well even at normal temperatures. Also, selected materials which retain hardness at temperatures specified are frequently unpredictable during sudden sharp increases in temperature above nominal values. Loss of strength with increase in temperature of various metals is shown in Fig. 1.

Creep causes a change in the geometry of individual parts and also affects tolerance stack-up and clearances within the unit. Fortunately, materials which retain their strength at high temperatures also have low creep and high retention of hardness.

Accelerated wear and galling characteristics of materials at high temperatures are of considerable importance to designers. Hydraulic equipment must operate under con-

ditions of very close fits and high unit loadings on adjacent surfaces moving with high relative velocities. It is difficult to obtain materials which combine strength, hardness, low creep, and resistance to wear and galling at high temperatures. However, this problem is solved to some extent by platings, coatings, or overlays of materials with desired characteristics on base materials which have other necessary physical properties.

For large temperature changes, thermal expansion results in loss of interference fits, changes in running fits, variations in clearances, and distortion of containing structures. All of these can have disastrous consequences on performance of the unit. Data which evaluate these variations in geometry under actual application conditions are not readily available because of the innumerable combinations of materials and geometries involved in high-temperature hydraulic units.

Available Fluids: It is generally agreed that hydraulic fluids presently available are satisfactory at temperatures to 400 F. However, for higher temperatures, available fluids exhibit adverse properties which complicate component design. Of particular concern to the designer is variation of viscosity and lubricity with temperature, Fig. 2. Lack of stability of these fluids produces permanent changes in viscosity, lubricity, flash point, density, retention of additives, and corrosion resistance, and causes extreme difficulty in attempting to generalize available performance data. Properties of high-temperature hydraulic fluids are listed in Table 1.

Thermal Shock: Of particular interest to designers is the lag between fluid temperature and body temperature of units with respect to ambient temperature. Based on actual thermal shock tests, components fabricated from aluminum would fail before a maximum ambient temperature of 1000 F was reached if it were not for this thermal lag. Consequently, prior to initiating any design, due consideration must be given to possible effects of thermal lag to obtain optimum results.

It has been shown that components can withstand considerably higher ambient temperatures than normally expected, as long as the thermal cycle is clearly defined. It is not enough to say that a component must operate at an ambient temperature of 1000 F. It also must be stated how long the component is to be at temperature and what rate of temperature rise and decay is expected. Also, careful consideration must be given to nonuniform thermal expansions within the unit.

High-Temperature Units: The immediate requirement for high-temperature hydraulic equipment appears to be in the −65 to +400 F range (Class 3). Life requirements for equipment in this category range to 200 hr with a desired goal of at least 560 hr at temperature. Because the usual duty cycle involves variation in temperature, a life of 200 hr at 400 F would be considered sufficient since the remaining 360 hr or more would be at somewhat lower temperatures.

Future requirements will progressively increase to maximum fluid temperatures of 550, 700, and eventually 1000 F. Low-temperature requirements will ideally be at −65 F but may, of necessity, be moved to 0 F because of fluid and seal difficulties at lower temperatures. The present state of the art is that the 400 F fluid-temperature requirement can be met with present equipment and with acceptable reliability.

Design Trends: Significant developments in high-temperature pump materials include design modifications of static and dynamic seals. In some instances, elastomeric static seals of the synthetic-rubber type have been replaced with loaded teflon or metal O-rings. For the low end of the high-temperature range, some of the silicones and Viton A appear to retain some elastic properties. Tests of these silicones and Viton A O-rings at 400 F indicate good performance. The limit for this material is 550 F as absolute maximum. One of the present difficulties with elastomeric seals in the high-temperature range is compression set with fail-

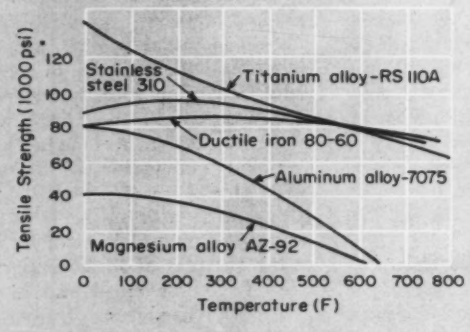


Fig. 1—Effect of temperature on strength of various metals

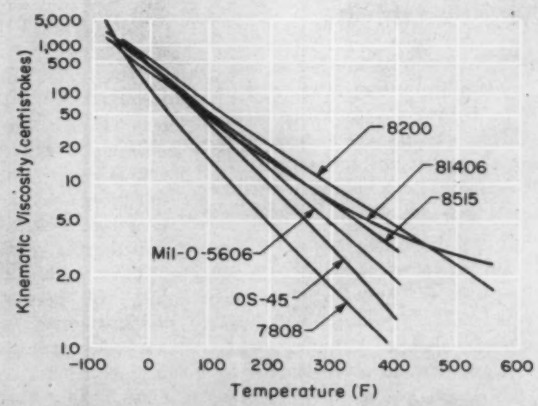


Fig. 2—Effect of temperature on viscosity of high-temperature hydraulic fluids

ure to reseal for subsequent thermal cycles.

Metal seals, although showing excellent characteristics, life, and retention of dimensions at high temperatures, have other difficulties in use. Tolerances must be maintained to a much closer limit than in the elastomeric seals, and the metal seals are less tolerant of surface finish and misalignments.

Tests indicate that Viton A in a conventional lip type of radial shaft dynamic seal is the best possibility at temperatures to 450 F. Above this temperature, the lip-type seal does not appear to be practical, and some type of face seal utilizing carbon or a metallic sealing element is required. However, these seals occupy considerably more space than the conventional lip-type seal.

One of the greatest shortcomings of high-temperature fluids appears to be in the category of lubricity. Testing has also indicated that from two to four times the pump life at temperatures of 400 F can be expected by using a lubricating fluid rather than synthetic high-temperature fluids. The present status of high-temperature pump development is that a life of from 1 to 200 hr at 400 F can be obtained with a silicate-ester fluid. Lives of approximately 20 hr are attainable with this fluid at 550 F. Insufficient data are available to make general statements as to life at 700 and 1000 F at the present time.

High-Temperature Actuators: The primary problem in design of high-temperature actuators is again materials and seals. Because of high external temperatures, use of titanium and high-strength stainless steels is indicated since the usual lightweight materials lose their strength rapidly above 500 F. Strength-to-weight ratios indicate that, although at low temperatures (to 300 F) titanium has an advantage over stainless steels, at working temperatures of 700 to 1000 F stainless steels are superior.

The major disadvantage of titanium is that of sensitivity to galling on sliding surfaces. One method of preventing this is by use of the Kanigen process of electroless nickel plating. Other disadvantages of titanium which are rapidly being overcome are the difficulties of machining and fabricating. An additional factor is high cost of raw material and the inconsistency of material obtained. Stainless steels show generally desirable properties although not of the same order of magnitude as ductile irons and high-strength steels at lower temperatures.

Actuator Seals: Elastomeric seals show marked disadvantages at higher temperatures. In applications where fluid temperature is sufficiently low, Teflon or Viton A can be used for internal seals and dynamic seals. For high temperatures where cooling is insufficient, some type of metal-reed seal is necessary with metallic O-rings for static seals. These configurations work fairly satisfactorily. However, extremely tight tolerances must be maintained and finishes, fits, and material combinations must be watched closely. Because of high friction forces of metallic seals, it is necessary in some cases to utilize long leakage paths with drains back to the reservoir for fluid which does pass the seal.

Electrical Problems: Perhaps the major materials problem in electrohydraulic servo valves is in the insulation of current-carrying parts of the torque motor or force motor used to operate the pilot-valve stage. Teflon and ceramic insulation are suitable to 400 F. Above this range, other high-temperature insulation materials must be used. For extreme temperatures, glass insulation can be used. Coils have been developed which can be used continuously at 550 F. Also, units are available that can be used intermittently at 700 F.

Another problem facing the servo-valve designer is null shift with temperature change. One method of overcoming this is to design a symmetrical valve whose output is not dependent upon maintaining extremely close tolerances. Main spools and pilot valves should both be of the push-pull design so that dimensional changes due to temperature variations cancel out. Control-valve spool, main spools, and sleeves made from the same material will minimize effects of thermal coefficient of expansion. Also, if the main-valve spool follows the pilot-valve spool so that effects of viscosity are eliminated, dynamic response of the valve will be essentially the same at high and low temperatures.

Special Fluid Systems: High-temperature fluids that have received considerable attention in the past are the liquid metals. Typical examples are alloys of sodium-potas-

Table 1—Properties of High-Temperature Hydraulic Fluids

Property	Mil-H-5606 A	OS-45 Type 3	OS-45 Type 4	Oronite 8200	Oronite 8515	Mil-L-7808 C (spec)	Mil-L-7808 C (Mfg A)	Turbo-oil 35	Versilube F-50
Base	Hydrocarbon	Silicate ester	Silicate ester	Silicate ester	Silicate ester	Diester	Diester		Modified silicone
Appearance	Red to clear	Amber to clear	Amber to clear	Amber to clear	Clear to light brown	Amber to clear	Amber to clear	Amber to clear	Water white to amber
Flash Point (F)	225	370	370	390	390	400 (min)	430	465	Over 525
Fire Point (F)	255	430	430	450	450				Over 650
Viscosity, (Centistokes)									
100 F	14.2	12.2	12.0	34.0	24.30	11.0 (min)	14.2	38.0	40
210 F	5.3	3.98	3.95	11.7	8.11	3.0 (min)	3.6	7.88	16
Specific Gravity	0.884	0.88	0.88	0.922	0.929		0.929	0.968	1.025 to 1.035
VTC	0.627	0.674	0.671	0.656	0.646	0.726	0.746	0.792	0.60
Pour Point (F)	−75 (max)	−85	−85	Below −100	Below −100	−75 (max)	−90	−65	Below −100

sium, cesium-potassium, cesium-lithium, cesium-sodium, and others of this general classification. Another ultrahigh-temperature fluid is mercury or alloys of mercury. In its pure state, mercury has several desirable characteristics, one of which is its inertness to chemical activity. This makes it particularly attractive in high-temperature applications which are concurrent with nuclear radiation or severely active atmosphere. Mercury or its alloys also possess high bulk modulus and high density which is desirable in servo-systems and applications in which a hydrodynamic type of pumping device is used.

From a paper entitled "Designing and Testing for High-Temperature Hydraulics," presented at the ASME-ARS Joint Aviation Conference at Dallas, Texas, March, 1958.

Evaluation of Niobium Alloys *as high-temperature materials*

By W. S. HAZELTON, Aviation Gas-Turbine Div., Westinghouse Electric Corp., Pittsburgh, Pa.

Properties of niobium, a potentially valuable alloy system, are compared to those of established alloys to evaluate the metal as a structural material for high-temperature use.

RESULTS of 100-hr rupture-strength tests of various alloys, including niobium, are shown in Fig. 1. Because molybdenum alloys have been under development longer, the better molybdenum alloys show a distinct superiority over niobium in rupture properties. However, niobium alloys show a marked advantage over one of the better conventional alloys. With the present emphasis on development of niobium-base systems, it can be expected that alloys with properties approaching those shown for the best molybdenum-base alloys will be developed in the near future.

Other properties, not usually considered as strength properties, are very closely related to design. Modulus of elasticity must be considered in many applications and, in parts subjected to buckling loads, is often of prime importance. In this respect, molybdenum is far superior to niobium. Fig. 2 shows the moduli of these elements with respect to temperature. Although this low modulus is a serious disadvantage of niobium, alloys of aluminum and mangesium have been used for important structural parts even though they, too, have very low moduli.

Thermal conductivity and expansion must also be considered in design and are often very important in determining durability of a high-temperature part. Table 1 shows how niobium and molybdenum compare in these properties. Niobium has a higher thermal expansion and a lower conductivity than molybdenum. With respect to these properties, one element cannot be said to be "better" than the other—they are merely different. Some applications need high heat-conductivity and some require limited heat transport.

High-temperature parts often fail by thermal fatigue caused by cyclic stresses induced in the parts. Magni-

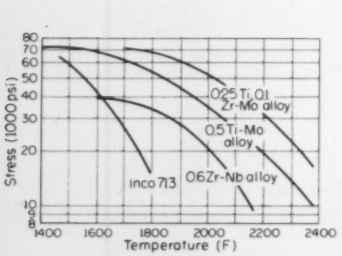


Fig. 1—Rupture-strength, 100 hr, of several well-known alloys and niobium

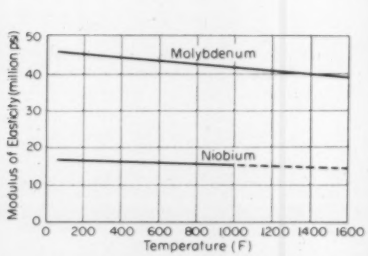


Fig. 2—Comparison of modulus of elasticity of niobium and molybdenum

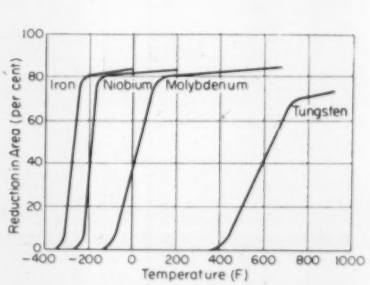
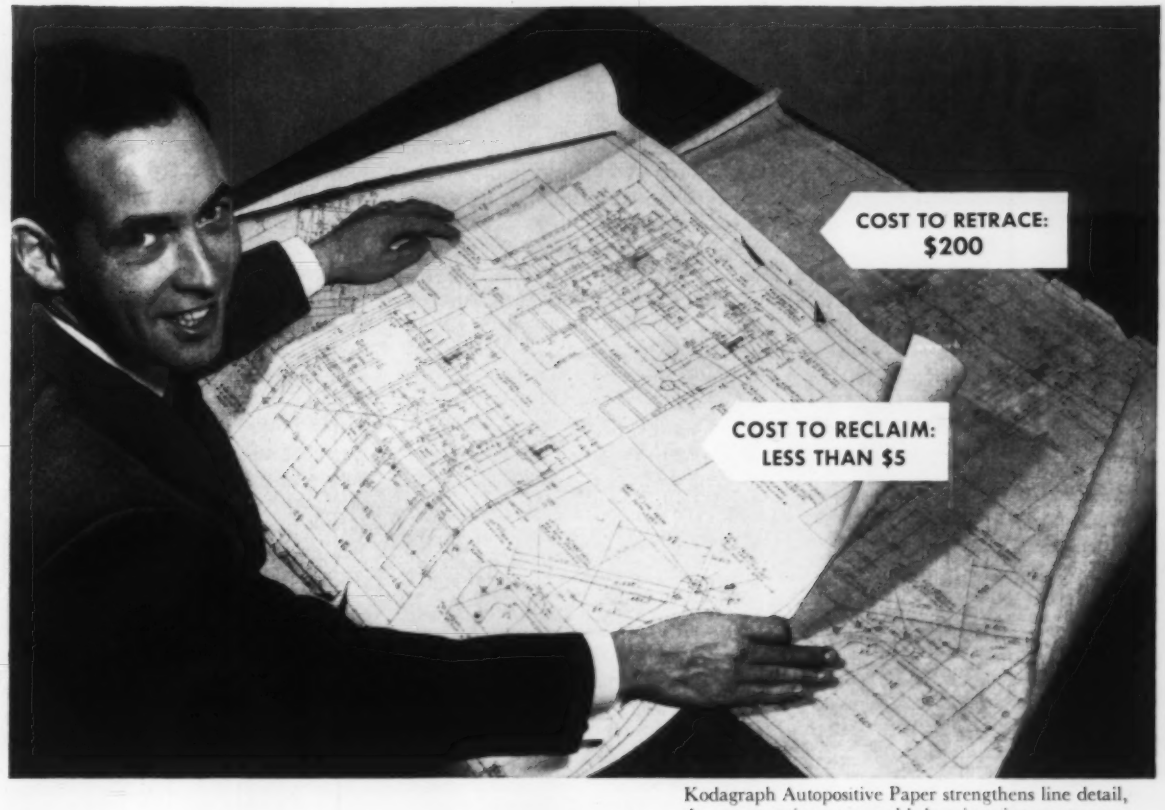


Fig. 3—Effect of temperature on ductility of niobium and other metals



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tude of these thermal stresses is directly related to thermal expansion, conductivity, and elastic modulus of the material. Both molybdenum and niobium have excellent thermal fatigue resistance because of their low coefficient of thermal expansion. Although molybdenum has a higher conductivity, niobium's lower modulus tends to offset this and both materials are resistant to thermal fatigue.

Table 1—Thermal Properties of Niobium and Molybdenum

Property	Condition	Molybdenum	Niobium
Thermal conductivity (Btu/sq ft/hr/deg F/in.)	212 F	800	377.5
Thermal expansion (in./in./deg F × 10^{-6})	RT-1800 F	3.4	3.8

Physical Properties: Often, the limiting factor in a high-temperature alloy is lack of ductility. When alloys of the high melting-point elements are investigated, a particular kind of ductility problem associated with crystal structure is encountered. Iron, chromium, tungsten, molybdenum, and niobium are all subject to a phenomenon known as ductile-to-brittle transition which is dependent on grain size, impurity content, temperature, and strain rate. Alloys of these elements are brittle and break easily when cold and/or under impact loading. As the temperature is lowered, these metals change their flow and fracture characteristics. Yield strength increases, and mode of fracture changes from a ductile shear type to the brittle cleavage type.

Fig. 3 shows how this ductile-to-brittle transition temperature varies for several of these elements. This is an approximate comparison only, since actual transition temperatures vary greatly for each metal and depend on grain size, purity, and type of test. Brittleness problems will be easier to overcome with niobium than with molybdenum.

Oxidation Resistance: High-temperature parts of aviation gas turbines, for example, are subject to a highly oxidizing atmosphere. The high melting-point elements considered have practically no oxidation resistance at the temperatures of the desired applications. Molybdenum is particularly poor, because its oxide, MoO_3, becomes volatile below 1000 F, and above 1450 F wears off in clouds of white smoke. From a practical standpoint, niobium is not much better although its oxide is not volatile.

Sufficient protection of molybdenum parts has been achieved by various coatings and claddings to make it useful for many applications, but these give only temporary and somewhat unsatisfactory results. Niobium can be protected in a similar manner. The problem of protecting niobium is much less severe, partly because its oxide is not volatile and because minute imperfections in the coating are not as deleterious. The most significant difference between molybdenum and niobium is the possibility of developing an oxidation-resistant alloy of niobium with adequate mechanical properties. Several investigators have already developed niobium-base alloys with excellent oxidation resistance to 2250 F.

Fabrication: Molybdenum can be forged into useful shapes and can also be rolled into bars and sheets. There is no apparent evidence of increased difficulty with niobium. In fact, experience indicates that less troubles will be encountered. One of the important aspects of proper fabrication of molybdenum is the necessity for fairly close control of residual cold work in the metal. With molybdenum of commercial quality, and with presently available alloys, a residual amount of cold work representing about 50 to 70 per cent reduction is necessary to give required strength and ductility. Too little cold work makes the molybdenum both weak and brittle, while too much lowers the recrystallization temperature and reduces its strength at temperatures above 2000 F.

Probably the first niobium-base alloys available commercially for structural parts will be strain hardened and will require controlled amounts of cold work to give them desirable properties. Limited experience with niobium alloys indicates that close control may be required until alloys are developed which do not depend on work hardening for their properties. Little is known about forging techniques, but the higher general ductility of niobium permits most rolling operations to be accomplished at or near room temperature. Both molybdenum and niobium are readily sheet formed by normal techniques, but molybdenum often must be heated to 600 to 1000 F for severe forming. Indications are that this may not be necessary with niobium.

Joining is a more serious problem. Welding by such processes as inert gas shielded arc welding causes the weld metal to pick up gaseous impurities. These can seriously embrittle both molybdenum and niobium. Many problems remain unsolved in welding both molybdenum and niobium, but the embrittlement problem seems to be of a much lesser magnitude in niobium.

Cost and Availability: Future availability of niobium and molybdenum is unknown, although it is felt that both will be in very adequate supply for specialized uses. At present, niobium is ten times more expensive than molybdenum for similar purity and product form. It is expected that with increased production, niobium prices will fall drastically, and may well be competitive with molybdenum in a few years.

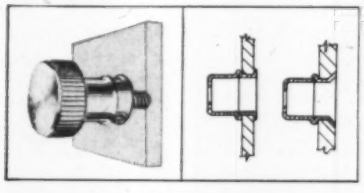
The low modulus of niobium permits more alloying without serious loss of ductility. There are two reasons why this tolerance for alloying elements is of primary importance. It allows high percentages of elements imparting oxidation resistance to be added to niobium without reducing ductility to an undesirable level, and it permits greater flexibility in designing alloys for high-temperature strength.

Since strengthening of commercial Mo and Nb alloys by cold work is lost by recrystallization, usable temperatures are limited by the recrystallization temperature. Also, the recrystallization temperature is lower with more cold work, thus making the strongest alloys useful at the lowest temperatures. It is most desirable, therefore, to develop alloys which are not dependent on cold work for their strength.

From a paper entitled "Potential Application of Niobium to Aviation Gas Turbines," presented at the SAE Annual Meeting in Detroit, January, 1958.

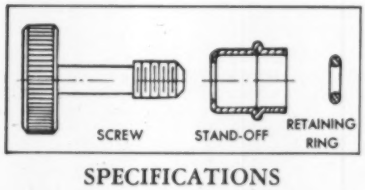
SELECT CLOSURE HARDWARE TO IMPROVE UTILITY, APPEARANCE, AND TO LOWER COST

QUICKLY INSTALLED SOUTHCO CAPTIVE PANEL SCREWS END MISALIGNMENT PROBLEM . . .



Simplicity of design contributes to clean, distinctive appearance and fast, low-cost installation. Stand-off is slipped into panel hole and secured by flaring. Screw is passed through stand-off and made captive by vinyl o-ring.

"Floating" screw design eliminates costly close tolerance manufacture and permits easy engagement regardless of panel distortion encountered under adverse use conditions.



SPECIFICATIONS

Material: Screw is brass, chrome plated; can be supplied in stainless steel. O-ring is vinyl plastic.
Overall length of screw: 1 3/16"
Depth of screw head: 1/4"

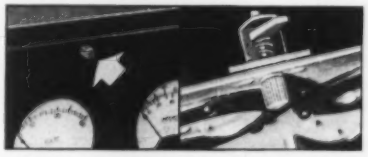
Sizes:

SCREW HEAD DIAMETER	THREAD SIZE
3/4"	1/4-20
5/16"	1/4-20, 12-24
3/16"	10-24,10-32

Length of thread: 3/8"

Screw head is supplied plain, as shown, or slotted for screw driver.

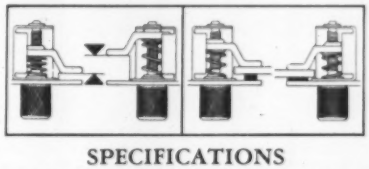
PRE-ASSEMBLED PAWL ADJUSTS TO DESIRED THICKNESS AND PRESSURE



This neat, compact Southco panel and door fastener is supplied assembled, requires but two rivets or bolts for low cost installation. It is available in three models—large, intermediate and midget.

The unique feature of Southco Pawl Fasteners is the fact that, by merely turning the knob, the pawl is adjusted to a wide range of frame thicknesses. This assures a tight grip without precision setting regardless of variations in frame or door dimensions or changes that are produced by wear or warping of sheets.

Pressure exerted by the pawl on the frame is controlled in the same way, by merely turning the knob. Against gasketed frames, pressure can be easily applied to compress the gasket.



SPECIFICATIONS

Knob: Cadmium or chromium plated steel.

Head Styles: Protruding ribbed or knurled knob; flush screw driver slotted for large size only.

	LARGE	INTERMEDIATE	MIDGET
Knob diameter	7/8"	5/8"	11/32"
Total width	2 1/2"	1 3/4"	1 1/8"
Total height	1 5/16"	7/8"	35/64"
Back of panel depth	1 23/32"	1 1/4"	7/8"
Knob length	1 1/8"	15/16"	9/32"

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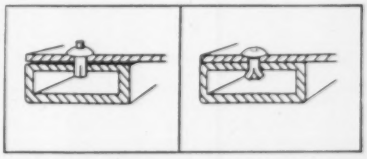

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Behavior of Reinforced-Plastic Laminates

at extremely high temperature

By N. B. MILLER and E. L. STRAUSS, Engineering Div., The Martin Co., Baltimore, Md.

HEAT-RESISTANT plastic laminates exhibit good mechanical and thermal properties in high ambient temperatures. Above 250 F, reinforced plastic materials tend to lose their strength at a slower rate than do the familiar light metals. The low thermal conductivity of plastics confines the highest temperatures to the exposed exterior surface while the remainder of the laminate remains appreciably cooler. Therefore, certain structures subject to heating will often operate more efficiently when made with reinforced plastics than with metal.

Laminates of glass-phenolic, glass-silicone, glass-polyester, and asbestos-phenolic were exposed to temperatures of approximately 3000 F for periods from 12 to 60 sec. Asbestos-phenolic laminates showed only slight surface erosion. Resin charring and weight loss were less extensive than for the glass-phenolic material, but delaminations were more pronounced. Compressive strengths of the asbestos-phenolic laminates were higher than those of any of the other plastic laminates.

High-Temperature Effects: Glass fabric-silicone laminates show no appreciable surface erosion and an extremely low weight loss when exposed to high temperatures. Glass fusion and resin charring are less severe than with other laminates. Delamination is widespread and material strength is poor.

The glass fabric-polyester laminates show severe surface erosion, glass fusion, and resin charring, as well as extensive delamination. Strengths compare favorably with phenolic-laminates for very short exposure times, but decrease sharply as exposure times increase.

Reinforced plastics have a limited life above the temperature at which decomposition of the resin occurs. The exact temperature at which decomposition takes place varies from one laminate to another but, at the present time, it is below 600 F for all resins. Decomposition does not occur all at once but takes place slowly and quite smoothly. Therefore, there is a time interval during which the laminate maintains its strength at temperatures above the decomposition point of the resin.

Silicone resins tend to soften as the temperature is raised. Softening is not permanent, and the silicones recover their room temperature properties upon cooling if they have not been heated beyond their decomposition points. The coefficient of thermal expansion of the resin is much greater than that of the reinforcing material in a glass fiber or asbestos laminate. There is some tendency toward breaking the bond between resin and reinforcement in a laminate because of high internal stresses set up which result in a loss of physical properties.

At temperatures above 1000 F, reinforcement is affected. Asbestos begins to lose its water of crystallization at about 1100 F, and the fibers lose much of their original strength as a result. Higher temperatures finally melt the fibers. Glass fibers melt in the temperature range of 1400 to 2000 F. There is, therefore, a progressive attack on various components of a reinforced plastic laminate. This attack begins with thermal stresses in the bond between reinforcing fibers at relatively low temperatures and advances through resin decomposition. It ends finally with destruction of the reinforcing fibers themselves. Severity of damage increases with exposure time. Nature of the damage sustained by various laminates is similar for equal exposure times.

Damage to glass fiber laminates at 3000 F progresses as follows:

1. Twelve-second exposure — Surface chars, and slight delamination occurs near surface.
2. Eighteen-second exposure — Surface resin is completely removed, and fusion begins on outer layer of glass fabric. Slight internal delamination is evident.
3. Twenty-seven-second exposure — Fusion of glass is widespread but still largely confined to the surface. Laminations spread to form visible gaps.
4. Thirty-six-second exposure—Damage to surface is extensive, and several layers of glass fiber fuse or erode. Extensive delamination between interior layers is evident.
5. Sixty-second exposure—Layer of fused glass covers the entire exposed surface. Material at the interior of the laminate begins to break down. Laminate warps appreciably with gaps formed in the interior from delamination.

Deterioration of the asbestos-phenolic laminates progresses in a manner similar to the glass-fiber laminates except that fusion of the glass is replaced by progressive dehydrating and cracking of the surface layers of asbestos. None of the coating materials of the laminates inhibit damage to the laminates to any appreciable extent. Table 1 shows thermal stability and strength factors of the laminates discussed.

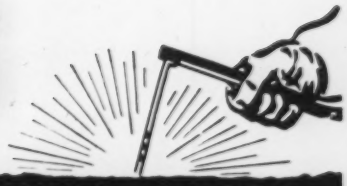
From a paper entitled "Effects of Elevated Temperature and Erosion on Reinforced Plastic Laminates," presented at the 13th Annual Technical and Management Conference of the Reinforced Plastics Div. of the Society of the Plastics Industry Inc. in Chicago, Ill., February, 1958.

Table 1—Properties of Reinforced-Plastic Laminates at 3000 F*

Material	Thermal Stability				Strength		Average Rating
	Weight Loss	Depth of Charring	Surface Erosion	Delamination	Exposed Area	Unexposed Area	
Glass-phenolic	3	3	3	1	2	2	2.33
Asbestos-phenolic ..	2	2	2	2	1	1	1.67
Glass-silicone	1	1	1	3	3	3	2.00
Glass-polyester	4	4	4	4	4	4	4.00

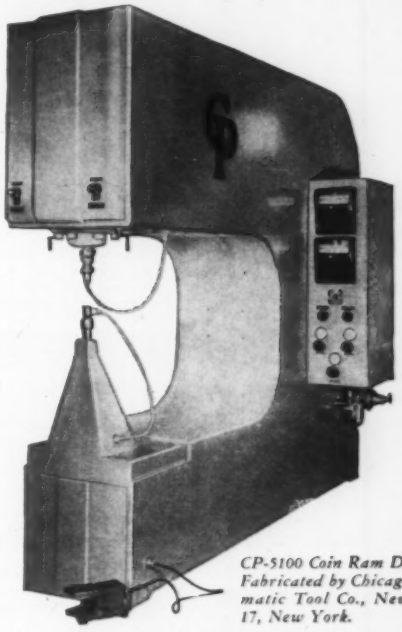
*Optimum material for high-temperature applications is rated as 1.

Weldynamics



ARC WELDING AT WORK CUTTING COSTS

How cost is reduced 37% ...weight cut 61% by Weldynamics



CP-5100 Coin Ram Dimpler. Fabricated by Chicago Pneumatic Tool Co., New York 17, New York.

Here's how Weldynamics has solved the problem of rigidity, accuracy and cost for a machine builder. With welded steel design the weight was cut from 18,000 pounds to 7,000 pounds *while holding alignment accuracy to .003"*. The cost was reduced from $2700 for a casting to $1700 for the weldment.

Weldynamics saves money because steel is 3 times as strong, 2½ times as rigid and costs a third as much per pound as cast iron.

How to put WELDYNAMICS to work for you

Lincoln field engineers, trained in Weldynamics, will help you design lower costs into your products. They stand ready to advise and recommend on procedures, equipment and electrodes to cut your welding costs.

New, 11th edition, "Procedure Handbook of Arc Welding Design and Practice" has 1300 pages, 1100 illustrations, 260 pages on machine design. $3.00 in U.S.A., $3.50 elsewhere.

Machine Design sheets published regularly give tips on welded design. No charge to Design Engineers and Production Supervisors. Just write us.

The World's Largest Manufacturer of Arc Welding Equipment

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THE LINCOLN ELECTRIC COMPANY, DEPT. 1130, CLEVELAND, OHIO

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Blind Rivets

Blind, Cherry, and Versa-Rivets for installation by one man from one side of the work are described in Bulletin T1-124. Selection procedure, ordering data and details on power and hand guns and accessories are included. 8 pages. Townsend Co., New Brighton, Pa. G

Circle 601 on Page 19

Clutches & Brakes

Descriptions and specifications of line of industrial brakes and clutches are found in illustrated Bulletin 500-A1. Their application to metal forming, winding, earth moving, paper, and rubber machinery is detailed. 32 pages. Fawick Corp., Fawick Airflex Div., 9919 Clinton Rd., Cleveland 11, Ohio. F

Circle 602 on Page 19

Quick-Connect Couplings

Most of special quick-connect, quick-disconnect couplings shown in illustrated, spiral-bound catalog feature remote disconnection by solenoid or lanyard action. Detailed specifications and application data are included. 26 pages. Snap-Tite, Inc., Union City, Pa. F

Circle 603 on Page 19

Transductors

Transductors measure large amounts of direct current although electrically isolated from the current-carrying conductor. They are illustrated and described in Catalog T-10. They can also be used to control. Specifications of available models are presented. 12 pages. Magnetics, Inc., Butler, Pa. F

Circle 604 on Page 19

Aluminum & Zinc Castings

Facilities for producing aluminum permanent mold castings and aluminum and zinc die castings are detailed in 12-section brochure with almost 100 photos. Processes and services offered are covered. Monarch Aluminum Mfg. Co., 9205 Detroit Ave., Cleveland 2, Ohio. F

Circle 605 on Page 19

400-Cycle Generator

Dimensional and performance data on NoBrush 400-cycle generators in ¼ to 10-kva ratings are contained in Circular E10. 2 pages. Georator Corp., Manassas, Va. C

Circle 606 on Page 19

Rheostat

Miniature 12½-w ⅞-in. diameter rheostat which weighs only 0.52 oz is described in illustrated Bulletin 157. It will operate at a maximum hot spot temperature rise of 300° C at an ambient of 40° C. 2 pages. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. J

Circle 607 on Page 19

Thermistor Cells

Specifications on signal strength, response time, flow, temperature, operating currents, mounting, and other data for designers of gas analysis appartus are presented in illustrated Bulletin TC-12-57 on thermal conductivity cells. Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J. D

Circle 608 on Page 19

Process Equipment

Facilities, services, and qualifications for producing process equipment for the chemical, food, pharmaceutical, heating, and other industries are outlined in data sheet. Typical equipment is illustrated. 2 pages. Niagara Welding & Boiler Works, Inc., 811 Linwood Ave., Niagara Falls, N. Y. F

Circle 609 on Page 19

Self-Adhering Felt

Information on self-sticking Quik-Felt, its uses, applications, and available stock shapes, is found on Data Sheet 187. It it also offered in special sizes and shapes. Prices are given. 2 pages. W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 610 on Page 19

Functional Tester

Rapid, automatic tests of complex relay systems and associated wiring can be made with the Model 250 functional tester, subject of an illustrated bulletin. Detailed application and operational data are included. 4 pages. Dit-Mco, Inc., 911 Broadway, Kansas City, Mo. I

Circle 611 on Page 19

High Power Density Motors

Standard, modified, and custom designs are available in a series of high power density electric motors, described in illustrated brochure. They are used in a broad range of environmental and performance conditions. Charts give specifications. 4 pages. Task Corp., 1009 E. Vermont Ave., Anaheim, Calif. M

Circle 612 on Page 19

High Pressure Coupling

H Series coupling for hydraulic or air pressures up to 10,000 psi in the ¼-in. size is subject of Bulletin 240. The quick-operating unit provides automatic sealing of lines when disconnected. Sizes made are ⅛ to 3 in. 2 pages. Snap-Tite, Inc., Union City, Pa. F

Circle 613 on Page 19

Testing Instruments

Illustrations and brief descriptions of 50 standard testing and calibration instruments are found in Catalog 58. Included are abrasion testers; production, control, and research equipment; thickness, compression, and recovery gages; and jigs, molds, and metalworking units, among others. 12 pages. Custom Scientific Instruments, Inc., 541 Devon St., Kearny, N. J. D

Circle 614 on Page 19

Alloy Fasteners

Standard and super alloy heat-resistant fasteners are listed in bulletin which includes a simplified A-N chart. Covered are A-N, N-A-S, and M-S studs, bolts, and screws meeting procurement specifications. 22 pages. Mercury Air Parts Co., 3826 Willat Ave., Culver City, Calif. L

Circle 615 on Page 19

Polyvinyl Materials

Wide variety of applications for the four basic forms of Geon polyvinyl plastic materials are illustrated in brochure. Calendering and coating, extrusions, insulation, molding, and foam and sponge uses are covered. Properties are given. 12 pages. B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio. F

Circle 616 on Page 19

Atomic Power Tubing

Two major applications for small-diameter tubing—fuel elements and heat exchangers—are given in Data Memorandum 20, "Tubing for Atomic Power." Typical end uses are listed and 10 inspection and testing methods are described. 7 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 617 on Page 19

Relays

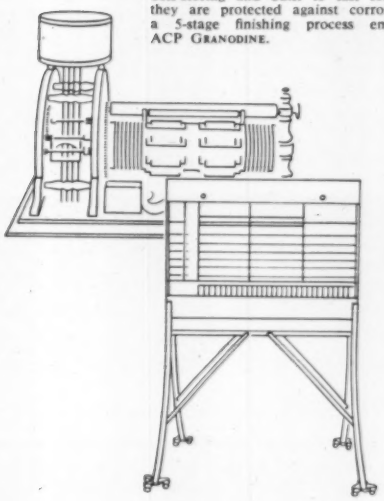
Many general purpose ac and dc, plug-in, printed circuit, and telephone type relays, laminated and open frame solenoids, and switch assemblies are described and illustrated in Engineering Catalog 58. Specifications of all types are given, along with dimensional drawings and performance data. 36 pages. Comar Electric Co., 3349 Addison St., Chicago 18, Ill. J

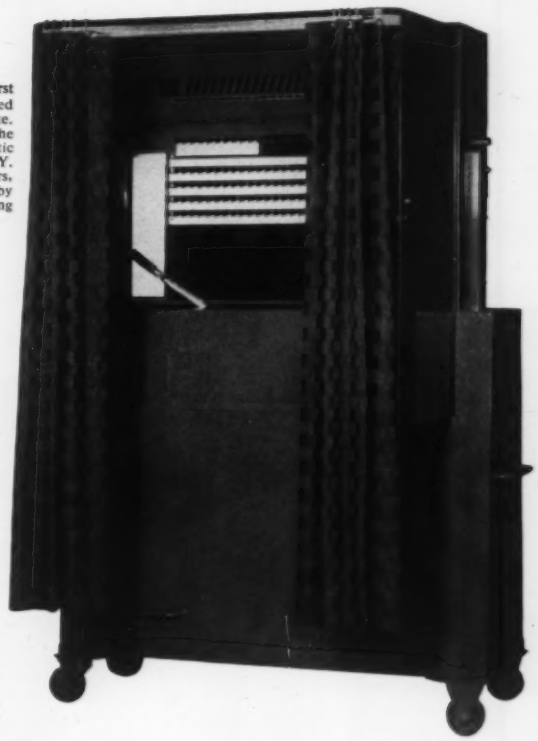
Circle 618 on Page 19

Distribution Equipment

Condensed information on low voltage distribution equipment and components is presented in 1958 General Catalog GEC-1023B. Covered are safety, disconnect, and open-knife switches; circuit breakers; lighting and distribution panelboards; wireway; switchboards; motor con-

The automatic voting machine—first patented by Thomas Edison—is now used by almost half the national electorate. Most of today's machines, such as the one at right, are made by Automatic Voting Machine Co., Jamestown, N.Y. Self-storing and built to last for years, they are protected against corrosion by a 5-stage finishing process employing ACP GRANODINE.

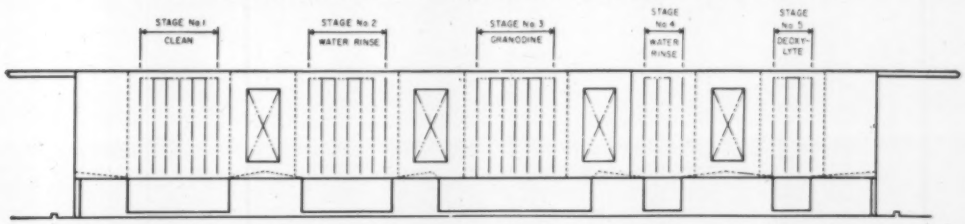




ACP GRANODINE ASSURES FIRMLY BONDED, CORROSION-RESISTANT FINISH ON VOTING MACHINES

There is a good chance that last time you voted, you cast your ballot on a machine like the one above made by Automatic Voting Machine Company, Jamestown, N.Y. Because these machines are necessarily in storage most of the time—often in unheated warehouses or basements of municipal buildings—it is essential that the metal be protected against corrosion. Automatic Voting Machine Company uses ACP GRANODINE for this reason. It chemically converts steel surfaces to a non-metallic phosphate coating. This not only increases adhesion of the finish, but also greatly improves the corrosion resistance of the finishing system, even when used in conjunction with a relatively thin and flexible paint film. ACP GRANODINE zinc phosphate coatings are economically applied by dipping, spraying or brushing. Why not investigate the advantages of ACP GRANODINE for your own finishing operation.

GRANODINE is a registered trademark of American Chemical Paint Company



Comprehensive ACP service program, including design of 5-stage spray finishing machine, was also an important reason why Automatic Voting Machine Co. standardized on ACP GRANODINE. Similar service is available to you in solving problems of corrosion, paint bonding, forming, drawing or other metalworking operations. Call on us.

Write for Bulletin 1380. *Describes the various types of ACP* GRANODINE; *gives the information you need to select the proper type for your particular application.*

AMERICAN CHEMICAL PAINT COMPANY, Ambler 44, Pa.

DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.

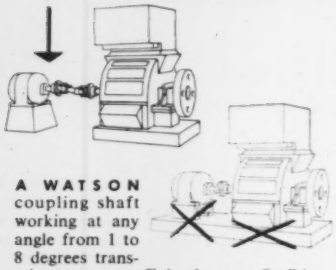
CHEMICALS ACP PROCESSES

New Chemical Horizons for Industry and Agriculture

Circle 478 on Page 19

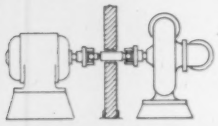
WATSON COUPLINGS **Engineering Notes**

How to Eliminate the Cost and Problems of Critical Alignment

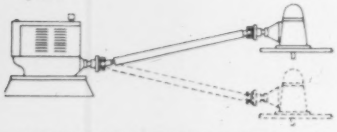


A WATSON coupling shaft working at any angle from 1 to 8 degrees transmits power as efficiently as a flexible coupling, yet offers substantial savings in design engineering time and installation cost. Angles up to 20 degrees can be handled (depending on RPM). No painstaking axial alignment is required; simple, low-cost concrete foundations poured on the site replace costly unit base plates.

In addition to substantial savings in engineering design and installation time and cost, the use of WATSON coupling shafts offers:



WIDEST LATITUDE IN LOCATION of driving and driven elements for best utilization of space, distribution of weight, isolation of motor or engine, provision for maintenance or working space.



PROVISION FOR RELATIVE MOVEMENT between driving and driven elements, either intentional or as a result of structural deflection or foundation shifts.

WATSON Coupling Shafts are promptly available in 9 sizes, 10 to 800 h.p., for speeds to 4,000 r.p.m. and more. Why not get the facts — now. 8-page Engineering Data Bulletin F-11 is yours for the asking; please address Dept. J-5.

WATSON **H. S. WATSON COMPANY**

1316 - 67TH ST., EMERYVILLE 8, CALIF.
1606 LASKEY ROAD, TOLEDO 12, OHIO 4

HELPFUL LITERATURE

trol centers; and other equipment. 144 pages. General Electric Co., Plainville, Conn. B

Circle 619 on Page 19

Pressure Regulators

"Pressure Regulators and How To Select Them" is title of bulletin which spells out important considerations for their application. Tables permit comparisons of basic characteristics of a variety of types. 28 pages. Kieley & Mueller, Inc., 64 Genung St., Middletown, N. Y. D

Circle 620 on Page 19

Fine Grain Steels

Steels with density and fine grain structure, produced by the Macro-Clean process, are suited for production of machine parts subject to stress during operation. Illustrated brochure shows applications for the alloy, stainless, carbon, and specialty steels. 4 pages. Green River Steel Corp., Owensboro, Ky. G

Circle 621 on Page 19

Impulse Counter

Technical details on a small Sodeco impulse counter are included in illustrated Bulletin E25. Its preselection system is described, and its electrical characteristics are presented. 4 pages. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y. D

Circle 622 on Page 19

Silicon Carbide

Properties, advantages, and uses of KT self-bonded silicon carbide are detailed in technical bulletin. Fabrication data, corrosive resistance, and application data are covered. Illustrations show a few applications. 4 pages. Carborundum Co., Box 337, Niagara Falls, N. Y. F

Circle 623 on Page 19

Hermetic Seals & Terminals

Offered to industry in an illustrated brochure is a consulting engineering service dealing with hermetic seals and terminals for electronic equipment and components. Also described is a new method for testing and inspecting parts made to user's specifications. Glass-Tite Industries, Inc., 88 Spectacle St., Cranston 10, R. I. B

Circle 624 on Page 19

Quick-Opening Manways

Readily opened from either side by removing one of two heavy duty pins, Lenape-Lacy manways afford full access to pressure vessels. Also available is an instant-latch model which permits venting of residual pressure before opening. Both lines are described in Bulletin 576. 6 pages. Lenape Hydraulic Pressing & Forging Co., Dept. 267, West Chester, Pa. E

Circle 625 on Page 19

Vibratory Feeders

Revised illustrated catalog on Vibra-Flow vibratory feeders contains specifications and other data on 13 standard vibratory feeders, three hydraulic and/or pneumatic feeders, and spiral elevator feeders. Specially engineered models, schematic

New *** Revolutionary

GRATON AND KNIGHT **NYCOR**

FLAT BELTING

Whatever your drive . . . you'll transmit maximum power longer with G&K Nycor belting. Your own tests will prove that Nycor belts deliver more horsepower over longer periods of time than ordinary transmission belting.

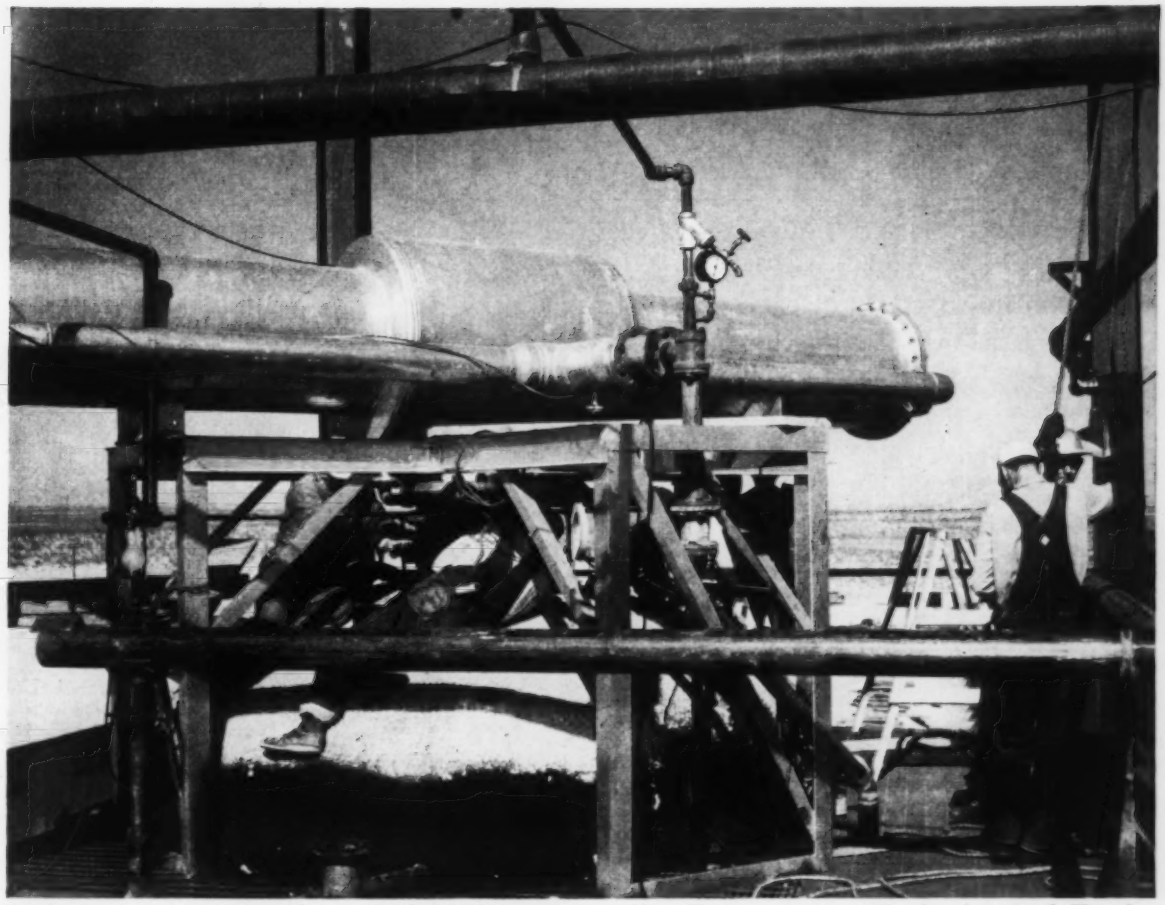
The stretchless feature of this belt eliminates take-ups and costly down time. In many instances conventional belting is replaced with Nycor at one half the width formerly used, reflecting tremendous savings on initial cost. LET US DEMONSTRATE THE DIFFERENCE!

Send For Brochure on Nycor Belting

GRATON & KNIGHT Company INC.
WORCESTER 4, MASSACHUSETTS

Circle 479 on Page 19

Circle 480 on Page 19



Erecting a crystallizer at a potash refinery in Carlsbad, N. M., operated by Pacific Coast Borax & Potash Co. This is one of seven crystallizers that were shop- and field-fabricated, then field-assembled by welding. They were not stress-relieved or heat-treated. There has been no stress-cracking in the nine months these units have been in service at the potash refinery.

NEW Ampco Metal Grade 8 stops stress corrosion cracking!

Important changes have been made in Ampco Metal Grade 8! It's *entirely new*—and completely obsoletes old ideas about fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

Now, with new, patented Ampco Metal Grade 8, you can . . .

1. Field-fabricate *without stress-relieving!*
2. Make field repairs, changes, and alterations *without heat treatments!*
3. Readily weld with any electric welding process! A. No pre-heat. B. No post-heat. C. No hot-short cracking!

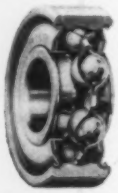
At one major oil refinery, field-assembled piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-cracking. Driers in a paper mill have handled 350° F steam at 125-lbs. pressure for more than a year without stress-cracking.

Let us prove it to you. Talk to your Ampco field engineer. Or write for details. *Ampco Metal, Inc., Dept. MD-5, Milwaukee 46, Wis. West Coast Plant: Burbank, Calif.—Southwest Plant: Garland (Dallas County), Texas.*

TS-1

AMPCO® AMPCO

Now you can use "Sealed" Miniature Ball Bearings in the inch size and precision grade YOU *require . . .*



RMB Filmoseal Bearings available in low-cost ABEC-1 as well as ABEC-5 tolerances.

Big news in the miniature bearing field! RMB's famous Filmoseal Bearings—the only sealed miniature bearings—are now made to low-cost ABEC-1 as well as ABEC-5 tolerances. This means designers can use these advanced design bearings even in those slightly less demanding applications where cost is a primary consideration. Designers can take advantage of such features as:

(1) Lubricant retention at high temperatures.
(2) Two-piece ball separators for high speeds.
(3) Coined crown-type ball separators for low torque.

Open radial Conrad-type bearings are also available in this new grade. A wide range of sizes is available from 3/16" (0.1875") to ½" (.5000") OD including many metric sizes.

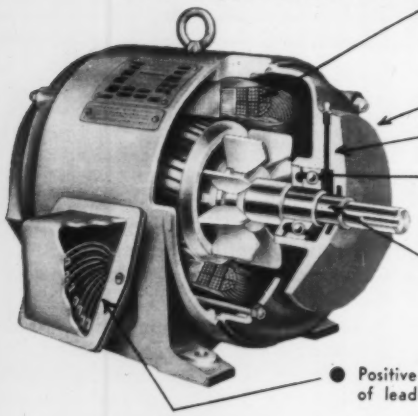
Write for your copy of the new RMB Miniature Bearings Catalog which gives full details on these as well as the entire line of quality RMB Bearings. Ask for Bulletin 62.

LANDIS & GYR, INC.
45 West 45th Street • New York 36, N. Y.

Circle 482 on Page 19

STAMINA of BROOK A.C. MOTORS is no coincidence!

Design is based on over half a century of experience. Built to surpass NEMA Specifications, yet cost no more than ordinary motors. Single and polyphase. All major types. 1 to 600 HP. Shipped from stock.



- Long-life windings are triple impregnated and baked.
- Internally-ribbed, shock resistant iron frame.
- Generous bearing lubrication capacity.
- Bearings two sizes larger than customary; yet, still replaceable from any standard bearing stock.
- High tensile steel, precision ground shaft and balanced rotor assembly.
- Positive identification of leads.

SINCE 1904

world's most respected motor

BROOK MOTOR CORPORATION

3553 W. PETERSON AVE., CHICAGO 45, ILLINOIS

BROOK MOTOR CORPORATION

Factory Representative, Warehouses, Dealers, Service Stations, in Major Cities.

Circle 483 on Page 19

layouts, and applications are also covered. 32 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 626 on Page 19

Panel Fastener

Engineering specifications and qualification test data for the Waldes QAF quick-action, stressed panel fastener are contained in two bulletins. Installation, operation, sheet preparation, available forms, and test results are detailed. 3 and 9 pages. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y. C

Circle 627 on Page 19

Teflon Hose & Assemblies

Nonswelling Teflon hose and hose assemblies, offered with leak-free compression fittings and stainless steel braid, is subject of illustrated folder. Chemicalproof material withstands heat to 450° F. Specifications of assemblies are given. 4 pages. Flexonics Corp., Flex-O-Tube Div., 2525 Jim Daly Rd., Inkster, Mich. J

Circle 628 on Page 19

Silicon Diodes

Bulletin SR-154 offers ratings and characteristics for silicon diode alternates for 1N91, 1N92, and 1N93 germanium diodes. They have low leakage valves and high temperature capabilities. 2 pages. International Rectifier Corp., El Segundo, Calif. L

Circle 629 on Page 19

Plastic-Steel Pipe

Information on Jal-Jacket rigid plastic pipe which is encased in a steel jacket is content of illustrated pamphlet. Product combines pressure-retaining strength of steel pipe with chemical-resisting qualities of unplasticized polyvinyl chloride pipe. 4 pages. Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa. F

Circle 630 on Page 19

Hose & Fittings

Details of various types of hose and fittings for a wide range of pressure and temperature service conditions are given in Catalog 4420. Hoz-lok-20 full-flow fittings are intended for medium-pressure applications. 8 pages. Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 631 on Page 19

Miniature Servo

Described in data sheet, Model 100-1 miniature servo is designed for servo repeater applications, but it is also suited as an isolation servo between synchro components or a synchro-controlled servo drive for resolvers, potentiometers, or shaft to digital converters. 2 pages. Librascope, Inc., 808 Western Ave., Glendale, Calif. L

Circle 632 on Page 19

Drafting Machines

Usable with the drawing board at any angle, the Glideline drafting machine requires no special machine adjustments or any counterweight attachments. It has instant fingertip control, 360° protractor with automatic 15° settings, and vernier

settings to 5 min. Bulletin G58 gives complete data. 4 pages. Glideline Corp., 300 S. Potomac St., Waynesboro, Pa. E

Circle 633 on Page 19

Variable Transformers

Designed to deliver a continuously adjustable voltage from alternating current power lines, Powerstat variable transformers are available for loads to 5.2 kva. Complete specs are given in Bulletin SE-L2581. 4 pages. Superior Electric Co., Bristol, Conn. B

Circle 634 on Page 19

Electronic Design

Company's facilities and activities in the design and manufacture of specialized electronic equipment is subject of illustrated brochure. Data are given on such items as motor-generator sets, power ground systems, flight simulators, and computer equipment. 20 pages. Jackson Electronic & Mfg. Co., 695 Johnston St., Akron 6, Ohio. G

Circle 635 on Page 19

Phosphate Coatings

Various Granodine phosphate coatings for steel are described in Bulletin 1380. This coating affords good paint bond and protects the metal from underfilm corrosion. 4 pages. American Chemical Paint Co., Ambler, Pa. E

Circle 636 on Page 19

Fused Magnesium Oxide

Technical properties of electrical grade Magnorite fused magnesium oxide are presented in bulletin. Material combines excellent electrical resistance with high heat conductivity, adapting it for use in heating elements. Norton Co., Worcester 6, Mass. B

Circle 637 on Page 19

Company Facilities

Engineering, design, and manufacturing facilities of this company in the fields of machine tools, tooling, and dies are explained in illustrated brochure. Described are its equipment and personnel. 16 pages. Centerline Inc., 29700 Euclid Ave., Wickliffe, Ohio. G

Circle 638 on Page 19

Thermoplastics Properties

Suited for cut-out or paste-up use, "Properties Chart" contains latest information on thermoplastics. Illustrations show typical parts produced to customer's specifications. Chart measures 7 x 12 in. Comco Plastics, Inc., 97-24 Albert Rd., Ozone Park 17, N. Y. D

Circle 639 on Page 19

Three-Way Air Valves

Dimensional information and specifications for three-way pneumatic pilot valves are given in folder. Fast-acting units require only 1/32-in. travel and only 2.6-lb actuating force. 4 pages. Logansport Machine Co., Logansport, Ind. J

Circle 640 on Page 19

Built-in Motor Protectors

Fifteen questions about Klixon built-in, three-phase, motor protectors are answered

12 NEW ¾" and 1"

Norgren AIR LINE FILTERS

Make Norgren the most complete line available!

For ¼" through 1½" Pipe Sizes
Up to 300° F Operating Temperature
Removable Bowl
5 to 250 psi Operating Pressure
Automatic or Manual Drain
Highly Efficient Water Removal

REDUCE COSTLY WEAR ON YOUR AIR EQUIPMENT

...with Norgren Air Line Filters

- **Now, 98 Models to choose from**—¼", ⅜", ½", ¾", 1", 1¼" and 1½".
- **Abrasive Solids and Corrosive Liquids** are removed from air lines, reducing equipment wear, repair and replacement costs.
- **Transparent or Metal Bowls**
- **Choice of 4 Filter Elements**—74, 64 or 25 micron...5 micron available in some sizes.
- **Automatic or Manual Drain**

For complete information about Norgren Air Line Filters, call your nearby Norgren Representative listed in your telephone directory—or **WRITE FOR No. 900 CATALOG**

If it's Norgren...It's Dependable.

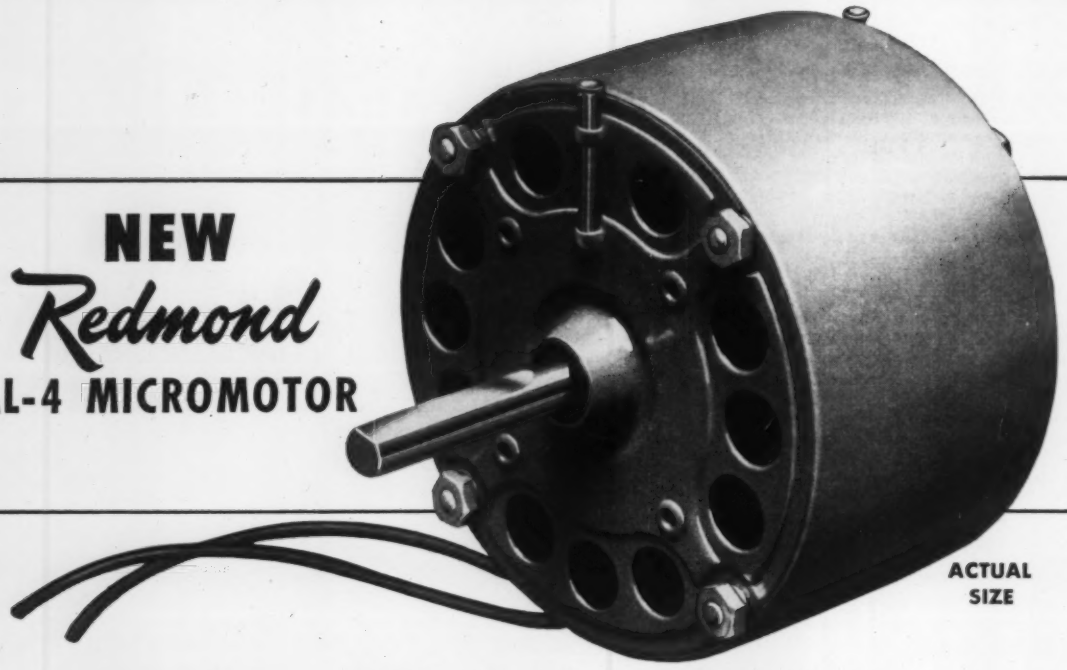
C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

Circle 484 on Page 19

MORE HORSEPOWER in an Economical,

NEW *Redmond* AL-4 MICROMOTOR



ACTUAL SIZE

Designed for a Wide Variety of Applications . . . or can be Tailor-Made for Specific Requirements

Here is a motor designed and styled to meet the modern demands for motors that are smaller, and lighter, and yet have increased output. It is ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and dozens of other applications.

The patented Redmond Tri-Flux design, which is illustrated and described in the box below, greatly increases the efficiency and starting and running torques of the new AL-4 over conventional motors of this size.

The Redmond Uni-Cast construction allows the precision manufacturing that results in a motor that is smooth-running and quiet in operation and that can be depended on to give years of service-free performance and whisper-quiet operation.

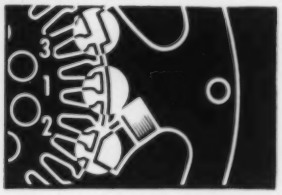
The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles. It is also available in odd voltages and frequencies, or in either open ventilated or totally enclosed construction. It develops 1/250th to 1/15th horsepower.

This modern motor can save money on a host of applications where economy is a factor and yet high quality is needed. If you are looking for a motor in volume quantities, let us know and we will have a sales engineer in your area contact you at once.

How Tri-Flux Design Improves Performance

The salient pole single phase induction motor has only one flux path—indicated by the white circle—between the field and the rotor. The motor is not self-starting—for commercial value a starting mechanism must be added.

The second white circle indicates the flux path added by wrapping a shading coil around the trailing pole tip. Power and uni-directional action are increased in this shaded pole induction motor, and it is now self-starting. This motor is now practical at low cost, and is used for applications requiring limited starting torque.



Note that a third flux path has been added at the leading pole tip. This was accomplished by Redmond's Tri-Flux design, whereby a "reluctance notch," which can be seen in the third white circle, is put in the leading pole tip. Efficiency and starting and running torques are greatly increased. New applications are opened to these improved, low-cost motors.

Compact, Lightweight, Quality Package

STANDARD AL-4 RATINGS

Open Ventilated FAN DUTY

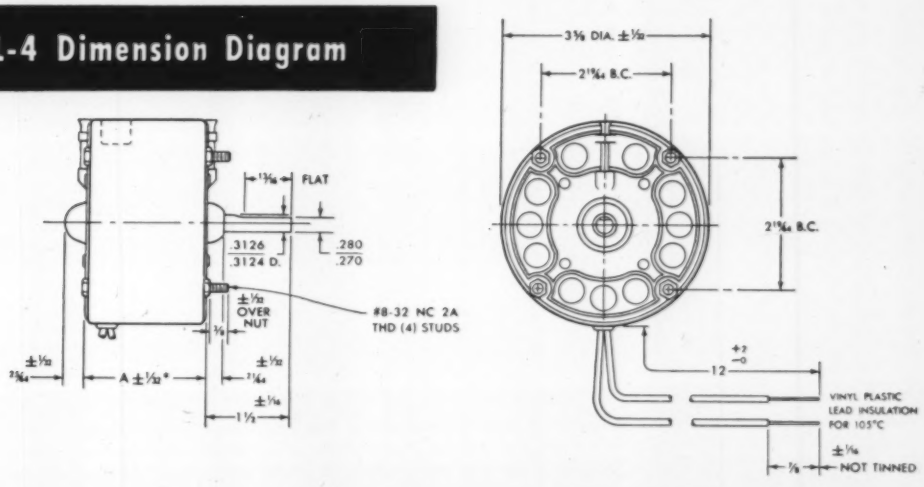
115V • 60 CYCLES • 4-POLE • 1550 RPM • ANY POSITION MOUNTING

Model Number	H.P.	Nominal Amps	Nominal Watts	Oz. in. Torque		A±1/32*	Weight lbs-oz.	Notes
				Start	Load			
AL4700A	1/15	2.25	150	18	45	3 9/32	4—10	(1) Horsepower ratings less than 1/75 horsepower available as developed for the specific application involved.
AL4701A	1/20	1.82	120	15	33	3 9/32	4—10	
AL4400A	1/25	1.6	105	13	27	2 23/32	3— 8	(2) Totally enclosed motors are available in all sizes in reduced horsepower ratings.
AL4300A	1/30	1.35	95	11	22	2 17/32	3—00	
AL4200A	1/40	1.2	85	9	17	2 5/32	2— 8	(3) All standard model numbers are clockwise rotation face shaft end of motor. Opposite rotation supplied on request.
AL4000A	1/75	.91	60	6	9	2 1/32	2—00	

Motors are supplied standard as shown. Also available are other features of special single or double shaft extensions, 5/16" and 3/8" shaft diameters, special casebolt extensions, sleeving over leads, other lead material including multi-conductor cords, feed-thru switches, plugs, terminals, thermal overload protectors, conduit clamps, conduit boxes, triangular mounting brackets, and special or extended oilers.

Other performance ratings for various voltages, frequencies, and loads can be supplied for your product. Our sales engineers will welcome the opportunity to assist you in developing the most practical motor for your applications.

Basic AL-4 Dimension Diagram



SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

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REDMOND

THE **BIG** NAME IN SMALL MOTORS

Circle 485 on Page 19

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The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.

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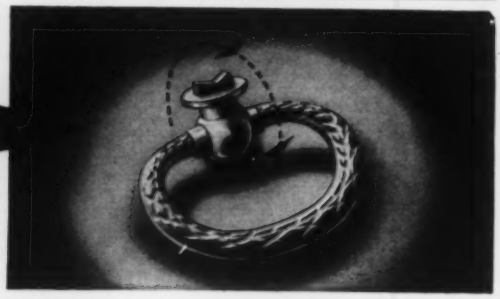
Circle 486 on Page 19

another unique
GRC die cast
zinc alloy component



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Circle 487 on Page 19

effectively in illustrated Bulletin PR-1243. Devices protect motors against overtemperature resulting from practically any cause. 4 pages. Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass. B

Circle 641 on Page 19

Heating & Air Conditioning

The complete Herman Nelson line of heating, ventilating, and air conditioning equipment is described in capsule form in Bulletin 701. Data are given on filters, unit heaters, convectors, fans, exhausters, console heaters, and many other products. 12 pages. American Air Filter Co., 215 Central Ave., Louisville 8, Ky. G

Circle 642 on Page 19

Pillow Blocks & Bearings

Described in illustrated Bulletin BU-101-A are various sizes and types of pillow blocks, flange blocks, and ball bearings. Construction details, performance data, and design information on all items are included. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 643 on Page 19

High Manganese Steel

Applicable for a wide range of uses, Rol-Man rolled and forged high manganese steel exhibits good ductility, wear resistance, and nonmagnetic properties. Suggested uses for this material are given in illustrated booklet, along with its mechanical and electrical properties. 12 pages. Manganese Steel Forge Co., Richmond St. & Castor Ave., Philadelphia 34, Pa. E

Circle 644 on Page 19

Fluid Couplings & Drives

Flexidyne drives utilize a combination of tiny heat-treated steel shot, housing keyed to the motor shaft, a drive rotor, and centrifugal force to apply power smoothly and with only initial slippage. Full information on these fractional to 1000-hp drives and couplings is presented in Bulletin A681. 6 pages. Dodge Mfg. Co., Mishawaka, Ind. J

Circle 645 on Page 19

Sludge Preventive

Research report reveals how Magna-Bar reduces corrosion and sludge formation in fuel oil storage tanks. This alkaline alloy bar is suspended in tank and neutralizes sludge forming catalysts and corrosive acids. 8 pages. Johns Mfg. Co. 670 Bound Brook Rd., Middlesex, N. J. D

Circle 646 on Page 19

Pneumatic Controllers

Catalog 53P-4000 discusses motion-balance pneumatic controllers with regenerative feed back circuits. Controller response characteristics and selection data are covered. 12 pages. Fischer & Porter Co., 489 Jacksonville Rd., Hatboro, Pa. H

Circle 647 on Page 19

Hard-Facing Electrodes

Chemical composition, properties, typical applications and packaging of 12 Haynes hard-facing electrodes are subjects covered in booklet. Eight iron-base alloys, three cobalt-base alloys, and Haystellite cast

tungsten carbide comprise these electrodes. 8 pages. Haynes Stellite Co., 30-20 Thompson Ave., Long Island City 1, N. Y. C

Circle 648 on Page 19

Valves

Gate, foot, swing check, cross check, angle check, vertical check, and cross valves are among the units described in Bulletin F-24. Valves handle hazardous liquids and are used in food processing or where corrosion resistance is required. 8 pages. Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 649 on Page 19

Molded Piston Cups

Bulletin AD-145 details construction, recommended service, and available sizes of synthetic rubber, leather, reinforced synthetic rubber, metal bonded, and metal reinforced cups for pump piston, hydraulic service, and for pneumatic equipment use. 6 pages. Garlock Packing Co., 423 Main St., Palmyra, N. Y. F

Circle 650 on Page 19

Pure Titanium

"Commercially Pure Titanium" is title of brochure describing properties and corrosion resistance of this metal. Chart compares corrosion resistant properties of titanium, zirconium, tantalum, and Type 316 stainless steel. 8 pages. Mallory-Sharon Metals Corp., Niles, Ohio. G

Circle 651 on Page 19

Motors

Design advantages of Lincoln Multiguard motors are pointed up in Bulletin SB-1345. These squirrel cage, Design B, protected, dripproof units are made in 1 to 40 hp ratings. Specifications are also given. 4 pages. Lincoln Electric Co., Cleveland 17, Ohio. F

Circle 652 on Page 19

Miniaturized Gears

Supplementary catalog E88 shows complete stock prices on 1/16 in. face width, precision Class I and II miniaturized gears. It also lists 1/32 and 3/32 in. face widths. Dynamic Gear Co., 20 Merrick Rd., Amityville, N. Y. D

Circle 653 on Page 19

Miniature Ball Bearings

Details on the new sizes of miniature ball bearings, including dimensions, tolerances, torque values, static and dynamic capacities, and limiting speeds, are covered in Catalog Supplement M1. Bearings have closer inner ring curvatures for increased static and dynamic load capacities. 6 pages. Barden Corp., 63 E. Franklin St., Danbury, Conn. B

Circle 654 on Page 19

Silicon Diodes

Up-to-date technical data and receiver design information relative to microwave silicon diodes for applications in the 300 to 70,000 mc frequency range are given in Catalog 58 S. Curves, nomographs, drawings and photos provide a clear picture of comparative diode performance.

New HIGH POWER 60 AND 400 CPS TRANSI-MAGS®

STANDARD LINE OF FAST RESPONSE

TRANSISTOR MAGNETIC AMPLIFIER

FOR SERVO MOTOR CONTROL

For driving AC servo motors in industrial and military servo systems which require hi-power, fast response and (static) high reliability.

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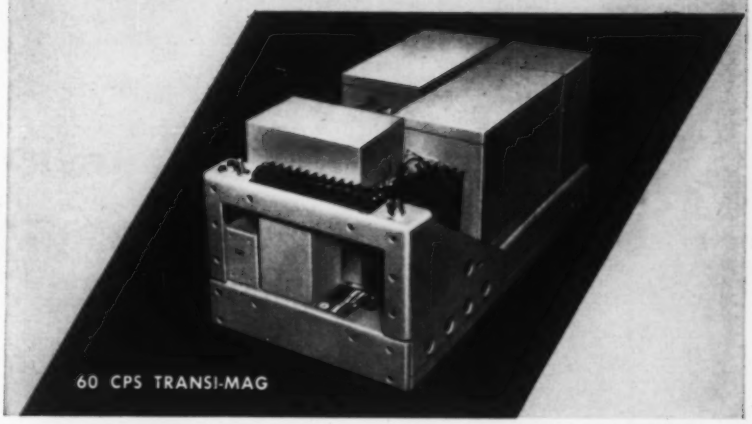

60 CPS PERFORMANCE SPECIFICATIONS

For complete 60 CPS and 400 CPS Transi-mag specs Write For Bulletin S-890.

MODEL A.C. INPUT / D.C. INPUT	TMA-1501 / TMA-1511	TMA-1551 / TMA-1561	TMA-1571 / TMA-1581	TMA-1601 / TMA-1611	TMA-1701 / TMA-1711	TMA-1801 / TMA-1811	TMA-1901 / TMA-1911
MAX POWER OUTPUT WATTS	50	100	120	175	650	1900	2800
TYPICAL SERVO MOTOR LOAD	Diehl FPF 49-9	Diehl FPF 49-12-1	Diehl FPF 66-11-1	Diehl FPF 85-18-1	Diehl ZP 105-2212-1	Diehl ZP 143-2247-1	Diehl ZP 162-2207-1
SENSITIVITY	A.C. Input — 0.3 volts A.C. for full power output D.C. Input — 0.15 volts D.C. for full power output						
RESPONSE	.05 seconds						
AMBIENT TEMPERATURE	— 55°C. to + 71°C						

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Circle 488 on Page 19

"IMAGINEERING"

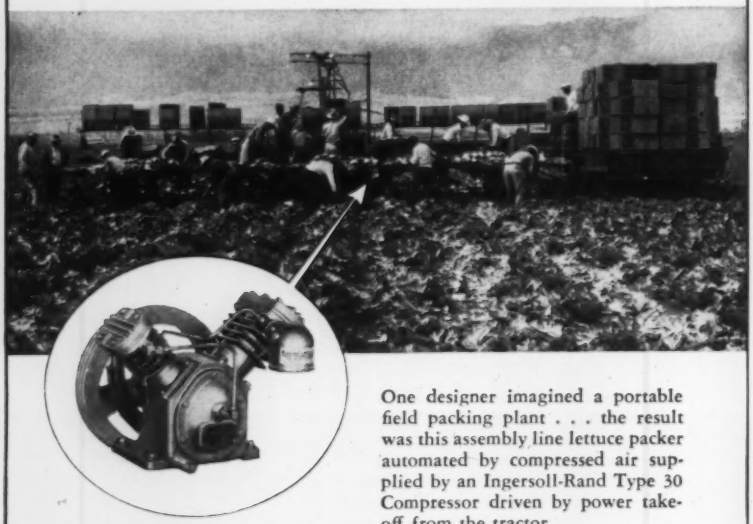
plays a big part in design planning

And if air or vacuum is required to operate some part of the planned product, Ingersoll-Rand can be of help.

Ingersoll-Rand devotes one phase of its manufacturing to a complete line of air-cooled compressors and vacuum pumps from ½ through 20 horsepower.

Thoroughly trained I-R field men can aid design people like yourself to plan an air or vacuum system into the equipment you are imagining. Then design board drawing goes easier . . . production problems are eliminated . . . and the final product is a smooth operating, trouble-free piece of machinery.

Why not consult with an Ingersoll-Rand specialist who can help you with your compressed air or vacuum problem. Call your nearest I-R branch office or write for complete information.



One designer imagined a portable field packing plant . . . the result was this assembly line lettuce packer automated by compressed air supplied by an Ingersoll-Rand Type 30 Compressor driven by power take-off from the tractor.

Ingersoll-Rand

3-810 **11 Broadway, New York 4, N.Y.**

HELPFUL LITERATURE

24 pages. Microwave Associates, Inc., Burlington, Mass. B

Circle 655 on Page 19

Steel-Bronze Bearings

Brief description of Beauideal bearings is given in folder. Bearings comprise steel and bronze inseparably bonded together for long life under extreme conditions. 2 pages. Beauideal, Inc., 867 S. Water St., Saginaw, Mich. H

Circle 656 on Page 19

Potentiometers

Dimensional and electrical drawings on eight models of precision potentiometers are highlighted in Catalog P103. Other information includes definition of terminology and a summary data sheet. 8 pages. Analogue Controls, Inc., 39 Roselle St., Mineola, N. Y. D

Circle 657 on Page 19

Resin-Bonded Lubricants

Preparation of metal surfaces for proper application of Molykote resin bonded lubricant coatings is explained in pocket-size Bulletin 115. Instructions for degreasing, phosphating, sandblasting, anodizing, dichromate treating, bright dip-treating, and phosphate fluoride coating are included. 24 pages. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn. B

Circle 658 on Page 19

Tool Steel

Precision ground tool steel that is preblued for immediate marking or layout is subject of descriptive Circular M69. Steel is available in all sizes from 1/64 x ½ in. to 3 in. thick and 14 in. wide. All sizes are 18 in. long. 6 pages. Brown & Sharpe Mfg. Co., Providence, R. I. B

Circle 659 on Page 19

Sample Design Part

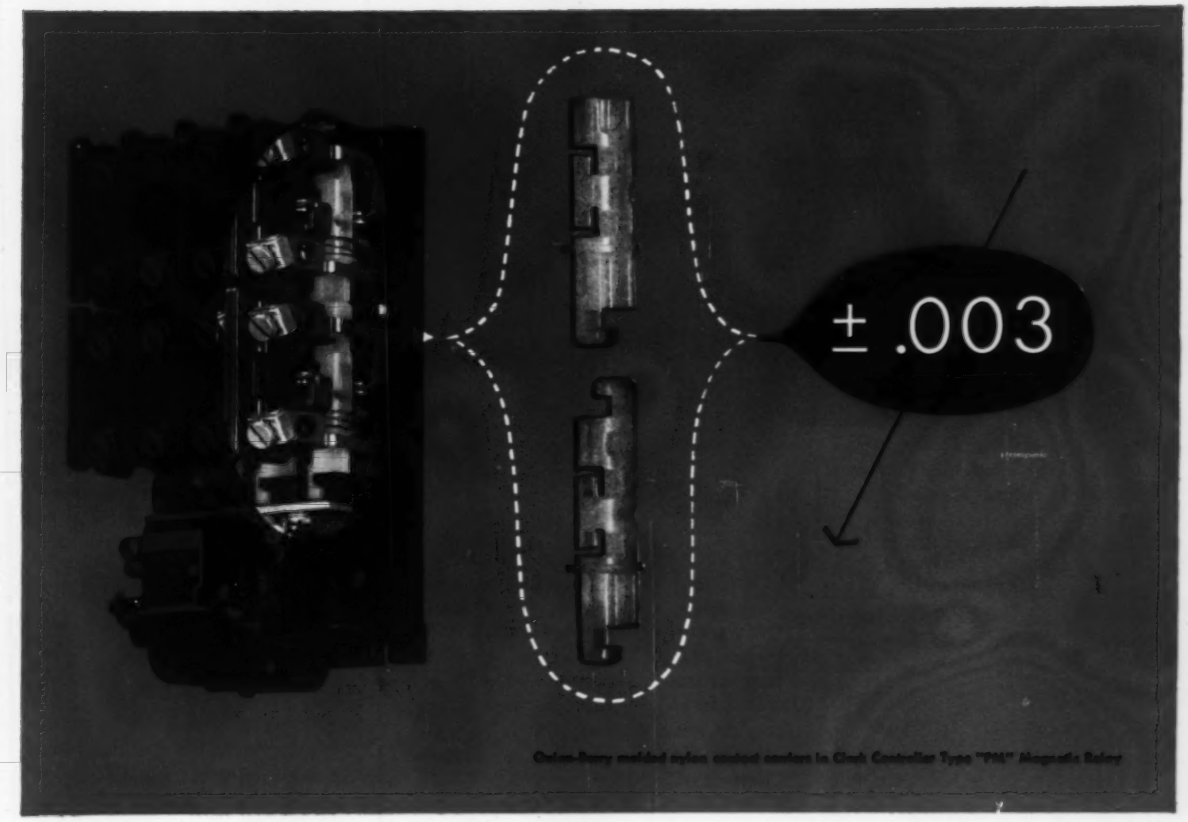
Bulletin DSS-2 schematically describes the conditions embodied in a design suggestion sample, produced by short-run methods using temporary tools. Sample is made from 3/32-in. thick SAE 1010 steel. It shows typical mechanical problems met with in terms of material type, temper, and thickness. Request sample and bulletin on company letterhead from Dayton Rogers Mfg. Co., Minneapolis 7, Minn. J

Thin Copper Tape

An actual sample strip of ultrathin, high-precision copper tape is contained in ASC data and sample sheet. Strip is only 0.00025 in. thick. Included is chart which simplifies the task of converting copper wire dimensions into equivalent copper strip. Write directly to American Silver Co., 36-07 Prince St., Flushing 54, N. Y. D

Valves, Strainers, & Driers

Catalog 103 contains detailed design and performance information on line of valves, driers, strainers, and other accessories for refrigeration, air conditioning, and industrial applications. Available only by writing direct to Henry Valve Co., 3215 North Ave., Melrose Park, Ill. J



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Extremely close tolerances, dimensional stability, high wear-resistance . . . these were the demanding specifications for the contact carriers shown above. Quinn-Berry's answer to the problem: careful choice of the right plastics material . . . precision mold design and manufacture . . . skilled pressroom craftsmanship. The result: components of consistent quality which contribute to the trouble-free performance of the Clark Type "PM" Magnetic Relay.

Step by step, under one responsibility and one control, every job is engineered from die design to finished product at Quinn-Berry where the "Unusual Is Routine" in molded thermoplastics. Consult with us in full confidence of the desired result.

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HOLDERS OF ALL TYPES OF THERMOPLASTICS

Circle 490 on Page 19

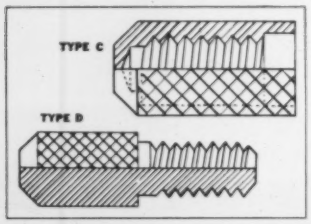
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Aluminum Threaded Inserts

for molding in plastics, rubber, and ceramics

Two new aluminum threaded inserts can be used separately or combined as male and female components of two halves of a molding. Units are for molding in plastics, rubber, and ceramics. Type C inserts are tapped with Class II threads to conform to ASME specifications in thread sizes from No. 4-40 to No. 1/4-28. Holes are



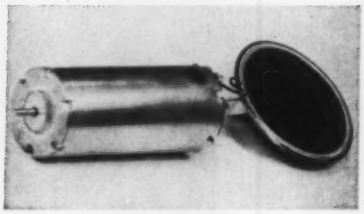
tapped to maximum depth for overall length and reamed after tapping. Type C is made with a countersunk hole and shoulder to accommodate Type D insert or other threaded stud. Type D insert is threaded in the same sizes and is proportioned properly to assure maximum strength. When used with Type C inserts, it can be screwed to butt flush with shoulder of female. Both inserts have coarse outside knurl to assure excellent holding power against high torque. They are available in plain aluminum as well as brass-plated and anodized finishes. **Yardley Precision Products Co.**, 30 Afton Ave., Yardley, Pa. E

Circle 660 on Page 19

DC Motor

is operated by solar generator or thermopile

Model EE 44-800 dc motor, designed for solar generator or thermopile operation, starts to rotate



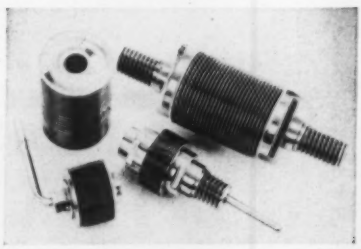
with an input of 600 mu w, 0.2 v, 3 ma, and can be modulated and used as a servomotor. Rotor contains no iron. Solar generators and photo resistors are available with outputs up to 300 mw. Motor illustrated is a 3.6-v unit; 2.4 and 8.0-v models are also available. **E. Vernon Hill & Co.**, P. O. Box 189, Lake Geneva, Wis. K

Circle 661 on Page 19

Welded Metal Bellows

in sizes from 1/4 to 18 in. OD

Welded metal leakproof bellows assemblies, designated Formweld, are made in a variety of sizes and special metals to provide accuracy and long life over a wide range of operating conditions. Sizes range from 1/4 to 18 in. OD. Applications include aircraft and missile instrumentation, fuel controls, shaft seals, oxygen regulators, steam traps, packless valve seals, and temperature and pressure sensors. Metals used include AISI 300 and 400 series stainless steel, Inconel-X, Ni-Span-C, titanium, zirconium, and other weldable, nonferrous materials. Bellows are designed with flat, spherical, stepped, and other plates as thin



as 0.003 in. ±0.0001 in. They provide greater fatigue resistance, less deformation under load, lower hysteresis, and increased temperature and corrosion resistance, compared with conventional hydraulically formed units. **Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co.**, 155 Hill St., Milford, Conn. B

Circle 662 on Page 19

Precision Balls

are fabricated of Pyroceram

New Pyroceram balls have tensile strength comparable to cast iron, brass, and bronze. Possessing excellent heat-resistant qualities, they remain hard at 2200 F. Balls are nonporous and take a high lapped finish. They resist corrosion, are unharmed by acid solutions that attack steel, aluminum, and copper, have excellent electrical properties at high temperatures, and are as

light as aluminum. Balls are available in a range of sizes. **Hartford Steel Ball Co. Inc.**, Hartford 6, Conn. B

Circle 663 on Page 19

Miniature Pump

is variable-displacement unit for pressures to 3000 psi

New PV-3906 variable-displacement pump is capable of flow up to 9.7 gpm at 24,000 rpm from a 2.4-lb package. Maximum recommended speeds are 12,000 rpm for aircraft

HITCO Insulation Products are designed for MISSILES ...Temperatures up to 5000°F.!

HITCO designs and produces a complete line of High Temperature Insulation Products for the demanding requirements of Missiles and Rockets.

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SOUTHWEST: Marshall Morris, 2850A W. Berry, Rm. 14, Fort Worth, Texas, WA 4-8679
NORTHWEST: J. L. Larsen, 5757 Oaklawn Place, Seattle, Wash., MOhawk 9311
CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston Street, Guelph, Ontario, Telephone: TAylor 2-6630

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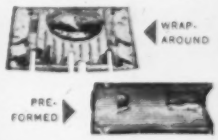

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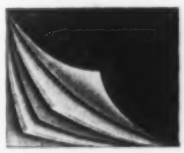
Removable Insulating Blankets combine top Acoustical and Thermal insulating efficiency with convenient flexibility for ease of installation and removal in jet airliners, cargo and Military Aircraft.



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Formed High-Density Fiberglas is designed for Thermal and Acoustical Insulation, and is a versatile protective insulation Material for a variety of Aircraft and Missile applications.

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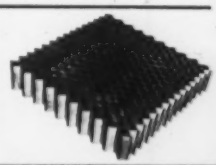
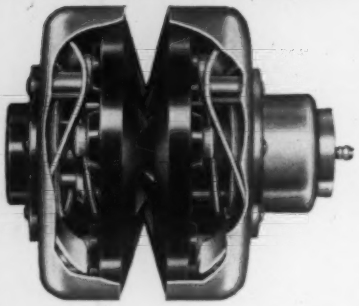
In Stainless Steel and a variety of other materials. Various thicknesses, core sizes and foil gages can be combined to meet your special requirements.



Hi-Lo Load-O-Matic Control Eliminates Pulley Slow Down



Hi-Lo Variable Speed Pulleys positively maintain the desired speed ratio over a wide range of load variation by means of an exclusive cam and cam follower assembly. This means:

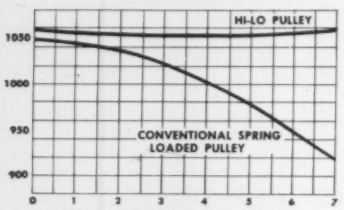
Pulley speed is independent of load and load changes. "Drag" is eliminated and high shock absorbency provided.

Pulleys do not compress belt due to spring pressure. Springs are not driving members. They act only to keep pulley faces in contact with belt.

Pulleys automatically regulate belt tension. Because of the cam assembly, belt is never under more tension than required by the load.

Double cams maintain constant belt alignment.

HI-LO PULLEYS COMPARED TO OTHER VARIABLE SPEED PULLEYS



PLUS THESE OTHER FEATURES:

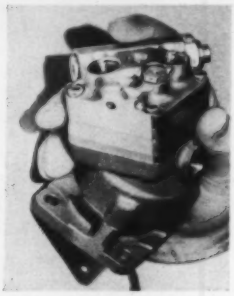
- Smaller in size than comparable units.
- Quickly and easily installed.
- Replaceable face assemblies drastically cut repair and replacement costs.
- Available in sizes from .5 to 5 hp., ratios to 2.5/1 (single pulley) 6.25/1 (double pulley).

Request details and prices. Ask for Bulletin A-458.

Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY 302 N. Lavergne Ave. Chicago 44, Ill.

Circle 492 on Page 19



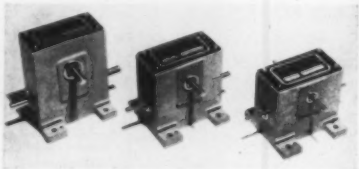
applications and 18,000 rpm for missile use. Pump power at speed of 24,000 rpm (intermittent) and pressure of 3000 psi approximates 17 hp. Unit is adaptable to a broad range of control methods such as flat or differential cut-off, constant hp, dual range, electrically depressurized, and load sensitive control. It provides weight reduction of 48 per cent and space saving of 70 per cent over standard unit of same capacity. **Vickers Inc.**, Detroit 32, Mich. H

Circle 664 on Page 19

Speed Reducers

in step ratios from 15:1 to 120:1

Type DE worm-and-wheel speed reducers are available in even step ratios from 15:1 to 120:1 in three shaft sizes of 1/8, 3/16, and 1/4 in., in both 48 and 64 pitches. Units



are available in ball-bearing design and oilless bronze units in over 175 different ratios and designs. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 665 on Page 19

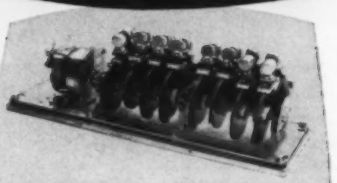
Cork Gasketing Material

combines cork-composition and cork-rubber properties

New cork gasketing material, designated Uniphase Cork, combines many of the features of cork composition and cork-and-rubber materials. It eliminates seepage and leakage of liquids and gases in applica-

NOW

Staley Programmers engineered for your application



- **DEPENDABLE**
- **RUGGED**
- **ADAPTABLE**
- **TROUBLE-FREE**
- **ECONOMICAL**

Staley Programmers are engineered for your specific application from standard components.

Designed for continuous duty, these units can control 1 to 100 circuits—or more—in required sequence and time intervals.

Equipped with sealed, unbreakable Staley Mercury Switches, these Programmers have established a high standard of reliable performance throughout industry.

Staley Programmers are used wherever accurate programming is required. Typical applications for OEM equipment and industrial processing control include:

- chemical machinery
- conveying equipment
- laboratory equipment
- metal-working machinery
- refinery machinery
- industrial furnaces
- rubber and plastic machinery
- pharmaceutical machinery
- weighing and packaging
- traffic controls
- electric signs

Staley Mercury Switches for long, service-free operation

For additional information, ask for:
Bulletin BP-600 on Staley Programmers
Bulletin BS-500 on Staley Mercury Switches

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Circle 493 on Page 19

NEWS FROM FLEXONICS

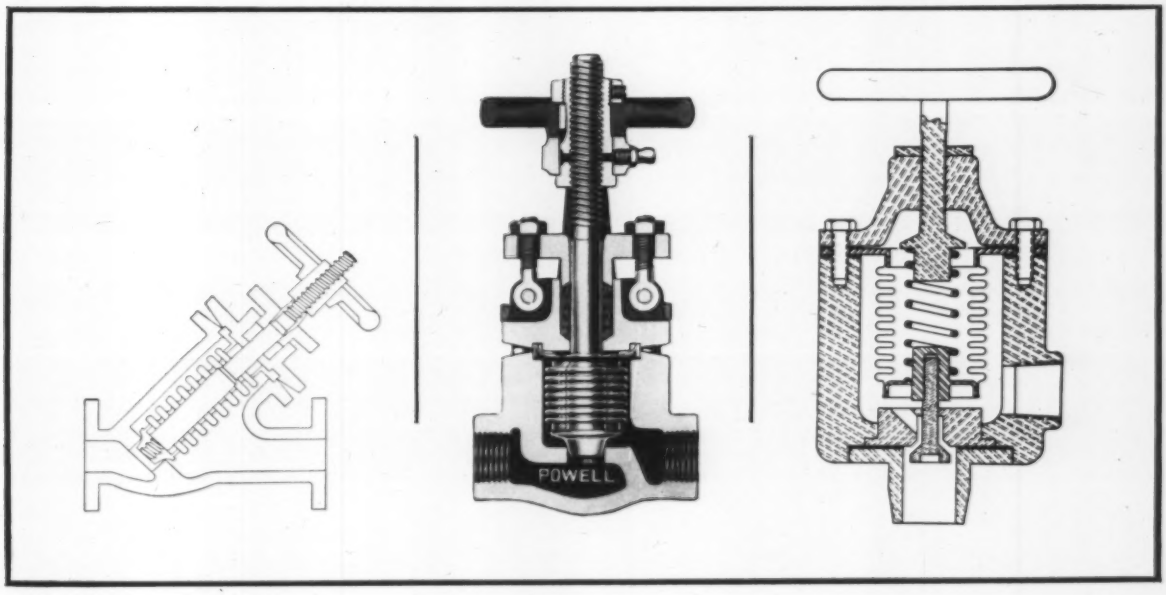
BELLOWS APPLICATION ENGINEERING

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

BELLOWS SEAL VALVES

the answer to industry's demand

for leakproof, maintenance-free valves for critical service



The advancing technology of the processing industries, plus the expanding demands of atomic energy, has radically changed valve design requirements. The increased handling of toxic and dangerous fluids has made leakproof valves mandatory. This same thinking applies equally to other types of equipment where an element in motion must be sealed. The result has been increased activity by designers in stem and shaft sealing projects.

Metallic Bellows Are the Economical Answer

Leading authorities agree that the metallic bellows seal is the answer to the problem. Flexonics is meeting this need today—economically, and in quantity production. The bellows are fabricated from a wide range of corrosion resistant metals. Leading valve manufacturers are applying this principle now. Bellows used in conjunction with conventional packing provide a safety feature without the maintenance problems of conventional packed valves.

FLEXON metal bellows can be supplied to meet virtually any condition of high temperature, high pressure and corrosive media. FLEXON bellows for these stem and shaft sealing requirements are available in stainless steel (321, 316 or 347), monel, inconel, brass and phosphor bronze.

The variety of valve types in which bellows may be used is limited only by the designer's imagination. The designs illustrated above are the kind commonly in use in industry today. The bellows is attached to a flange mounted between the valve body and bonnet. The stem of the valve is attached internally to the bottom plate of the bellows.

Engineering Assistance

As the pioneers of corrosion resistant bellows, Flexonics Corporation is well qualified to assist you in bellows seal valve design problems. All the know-how of over 18 years' experience in this specific field is at your disposal.

Whatever your bellows application problems, the Flexonics Application Engineering Staff will be pleased to assist you. For specific recommendations send us an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide. For handy reference see the Flexonics catalog in Sweet's Product Design File.

B-47

BELLOWS DIVISION

Flexonics *Corporation*

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Circle 494 on Page 19

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MEET TODAY'S COMPETITION

AND

INCREASE YOUR SALES

Bring your Assembly and Machining Methods Up-to-Date and Cut Costs

with DPS POWER METHODS

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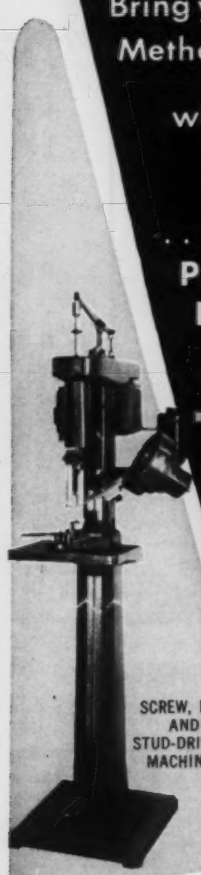
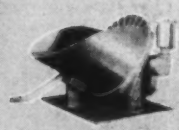
that will mean more SALES ACTIVITY and protection to your PROFITS through ability to meet the price resistance that exists Today!



SCREW, NUT AND STUD-DRIVING MACHINES

VIBRATORY PARTS FEEDERS

ROTARY BARREL TYPE SELECTIVE FEEDERS



HIGH CAPACITY HEAVY-DUTY FEEDERS

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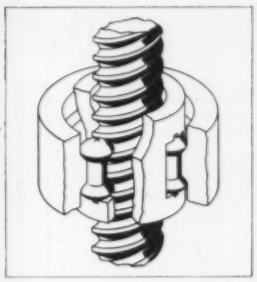
2801-A W. FORT ST. DETROIT 16, MICH.

tions where neither cork composition nor cork-and-rubber have been satisfactory. Made with a continuous-phase elastomeric binder that surrounds and embeds cork particles, material forms an impervious barrier to fluids. It has greater resistance to contained fluids than other resilient gasket materials because binder more closely approaches chemical inertness of cork itself. Material is resistant to fungus attack and has excellent ozone resistance. It seals at flange pressures as low as 100 psi, and loads as high as 4000 psi will not crush it or cause it to extrude. **Armstrong Cork Co.**, Lancaster, Pa. C

Circle 666 on Page 19

Antifriction Bearing

has freewheeling feature



Roton antifriction bearing converts rotary to linear or linear to rotary movement when designed into nut and screw assemblies. Covering a wide range of work loads and power inputs, assembly features caged bearings rolling within an annularly grooved nut functioning as outer race, with helical thread lead of screw acting as inner race. Planetary action results in mechanical reduction of linear advancement relative to thread lead, supplementing speed reducers and gear boxes, or eliminating them when ratio permits. Unit provides for freewheeling at a predetermined end of travel pending reversal of motion. **Roton Products Div., Anderson Co.**, 1075 Grant St., Cary 40, Ind. J

Circle 667 on Page 19

Mounting Screw

eliminates retaining nut

New screw incorporates two types of threads, nibs under the head, and a special point. Left-hand

Circle 495 on Page 19

EATON

DYNAMATIC®

SINGLE PACKAGE

FRACTIONAL HP AJUSTO-SPEDE® DRIVES

Provide Stepless Adjustable Speed from an AC Power Source

Sizes and Types for Hundreds of Industrial Applications

Dynamatic Ajusto-Spede® Drives, part of a family of diversified eddy-current equipment, provide an economical solution to many adjustable speed drive problems.

The Fractional Horsepower Ajusto-Spede, a single package design, combines an AC constant speed induction motor, eddy-current coupling, and electronic control. Standard modifications provide for the addition of electrically operated fail safe friction brakes, or speed reducers with numerous gear reduction ratios.

Fractional Horsepower Ajusto-Spede Drive power is taken directly from 115/220 volt, single phase or 220/440 volt, 3 phase lines. Sizes are ¼, ⅓, ½ and ¾ horsepower at 1600 RPM; ½, ¾ and 1 horsepower at 3200 RPM.

Friction brakes for quick stopping or fast cycling operation are furnished in two capacities—1½ and 3 pounds feet of torque.

Gear reductions with 10 ratios between 5-to-1 and 100-to-1 are supplied with 1600 RPM and 3200 RPM Ajusto-Spedes.

Ajusto-Spede® Advantages

- ★ **Constant torque speed range: 25 to 1 with either 1600 RPM or 3200 RPM Ajusto-Spedes.**
- ★ **Control accuracy: 2 per cent of top speed at any point within the speed range.**
- ★ **Minimum wiring to power line.**
- ★ **Remote "one knob" control operation up to 100 feet.**
- ★ **Rugged plug-in type integral one-tube electronic control.**
- ★ **Permanently sealed grease-packed bearings.**

For more detailed information, write for your free copy of the Dynamatic Fractional Horsepower Ajusto-Spede Bulletin, FAS-6.

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DYNAMATIC DIVISION
MANUFACTURING COMPANY
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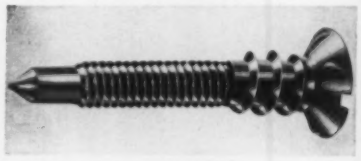
Circle 496 on Page 19



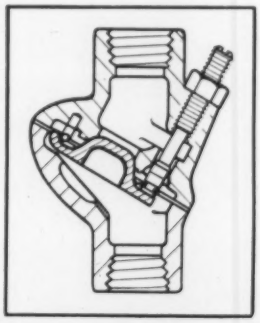
threads and nibs under the head permit screw to be driven into a panel and retain itself, and standard right-hand machine - screw threads form a stud. Special point helps to bring nut into alignment, eliminates cross-threading, and permits blind applications. Screw is recommended for mounting various types of electrical equipment onto panels, and for other applications where studs are required. It has applications in plywood, masonite, composition board, and other materials. Any standard head style is available, and screw size and length of both threads can be varied. **Shakeproof Div., Illinois Tool Works**, St. Charles Road, Elgin, Ill. J

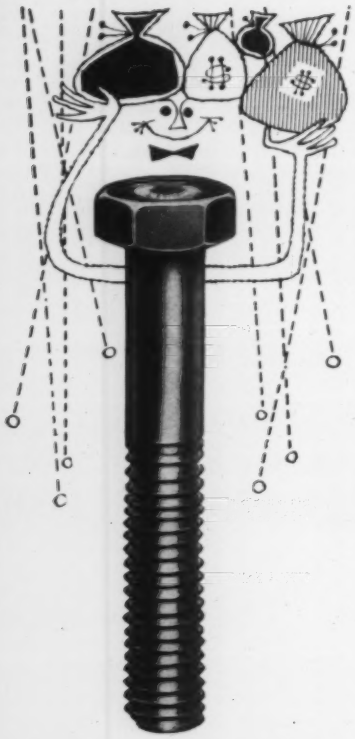
Circle 668 on Page 19

Flow-Control Valves

in sizes from ¼ to ¾ in. NPT

Micro-Trol flow-control valves permit precise control of air, gas, or low-pressure hydraulic flow with unrestricted return. They feature locked screw adjustment, new combination of controlling elements, threaded stem, and molded nylon flapper. Lower range of flow rates is metered by adjusting position of ground cylindrical stem within a concentric bore in valve body. As regulating portion of stem clears bore, stem end contacts flapper, lifting it off its seat. Flow is then controlled by clearance between flapper and seat. Flow rate adjustment is retained by an external lock nut





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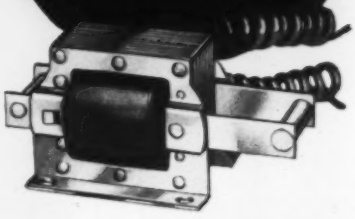
Circle 497 on Page 19

DORMEYER SOLENOIDS

Engineered TO OUTLAST PRODUCT LIFE



MILLIONS OF CYCLES constitute standard DORMEYER dependability. DORMEYER solenoids serving this long *and longer* continue in smooth operation in countless products today.

All types and sizes available to meet your needs. DORMEYER quality means dependable, long-lasting, trouble-free circuit operation...and DORMEYER production facilities mean low unit cost, on-time delivery.

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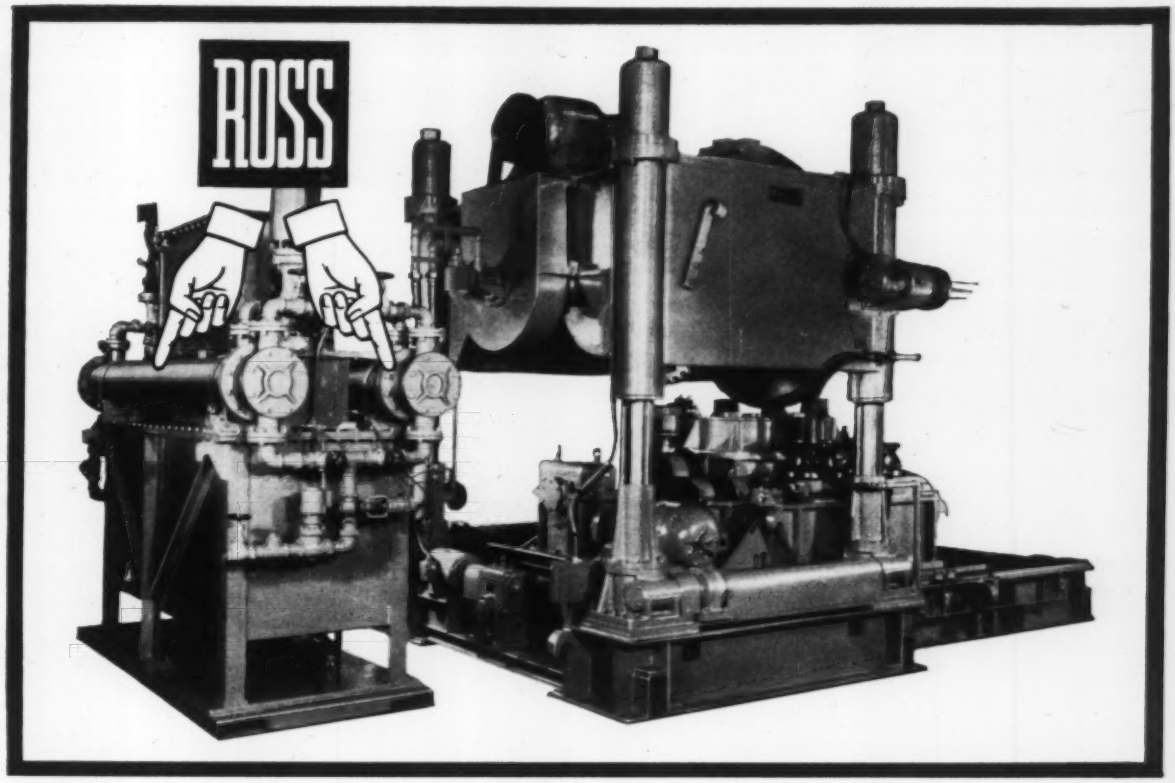
Circle 498 on Page 19

OIL COOLING BY ROSS...



for the "hot" job performed by this McKay Rotary Transformer

Shown serving a McKay resistance weld tube mill, this McKay Rotary Transformer is one of several sizes covering a range of 22,000 to 300,000 amperes. Important to its dependable performance is the forced oil cooling system.

"Oil, which is a non-conductor," says The McKay Machine Co., "is forced into direct contact with the high voltage primary and the inner and outer (copper) secondary castings—thereby removing heat at its source and increasing overall efficiency."

Incorporated into the design of this unit are two Ross Type CP Exchangers to keep the circulating oil at safe temperatures. "The Ross unit was selected because of its compactness and reliability," states McKay. "It is important that no water get into the transformer oil, because this would ruin its dielectric properties. Hence, the heat exchanger must be so constructed that this cannot occur. The design of the Ross unit makes *such leaks very unlikely.*"

Like The McKay Co., countless other makers of all types of prime equipment choose Ross Exchangers because they are "compact and reliable." Unrivaled for ruggedness and thermal efficiency, they're designed for every type of heat transfer requirement—oil, gas, water, air and hydraulic fluid.

Write today for detailed information on these completely pre-engineered and fully standardized units. Available in a wide range of sizes to meet your specific needs. Bulletin 2.1K5 gives you all the facts. American-Standard*, Ross Heat Exchanger Division, Buffalo 5, N.Y. In Canada: American-Standard Products (Canada) Limited, Station D, Toronto, Ont.

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American-Standard Products

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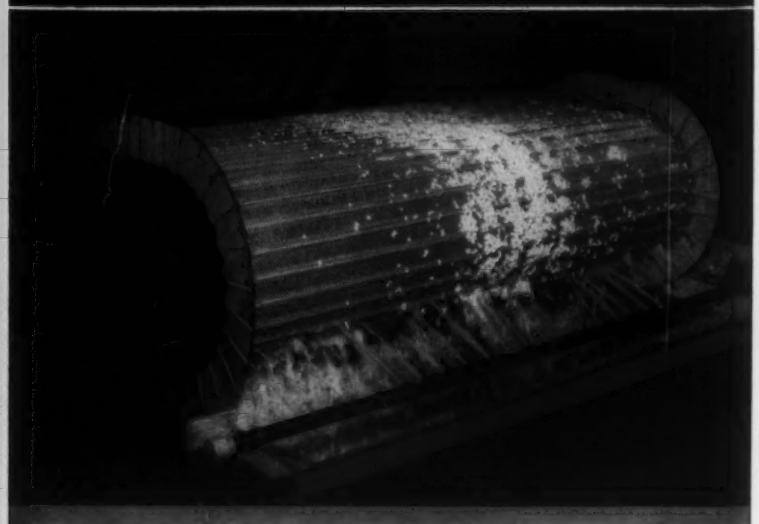
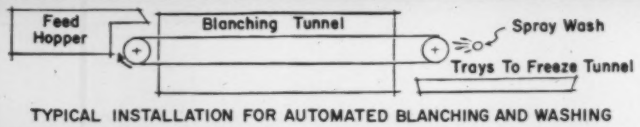
ROSS HEAT EXCHANGER DIVISION

Circle 499 on Page 19

Cambridge WOVEN WIRE BELTS





TYPICAL INSTALLATION FOR AUTOMATED BLANCHING AND WASHING

Continuous processing on open mesh belts increases product uniformity

Open mesh Cambridge Woven Wire Belts allow liquids, gases, cold or heat to flow freely through the belt and around the product for fast, uniform processing. Metal parts, food, chemical or ceramic products carried through wet, dry, hot or cold processing operations on endless Cambridge belts means increased production and lower operating costs. Here's why:

CONTINUOUSLY MOVING BELT ELIMINATES BATCH PROCESSING; belt to belt flow of materials reduces manual handling, labor costs.

ALL-METAL CONSTRUCTION IS HEATPROOF, RUSTPROOF; takes up to 2100° F. or sub-zero temperatures; resists corrosive attack; has no seams, lacers to wear or break.

SPECIAL SURFACE ATTACHMENTS AVAILABLE; raised edges, cross flights to keep product on belt during inclined movement.

Whether you design machinery for your own use or for resale, your Cambridge FIELD ENGINEER can explain how the many advantages of Cambridge belts make automated processing practical and economical. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your operations. Call now. He's listed in the classified phone book under "BELTING, MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N, Cambridge 5, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

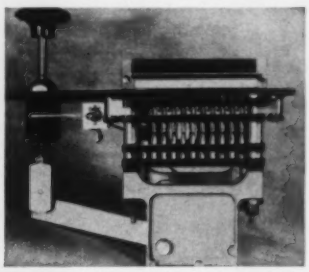
on slotted adjusting stem. Valves are available in sizes from 1/4 to 3/4 in. NPT. **Valvair Corp.**, 454 Morgan Ave., Akron, Ohio. F

Circle 669 on Page 19

Multiple Switch

automatic unit uses prepunched code cards

Cardmatic automatic multiple switch is a self-actuating mechanism which has 187 single-pole, single-throw floating contacts housed in a sandwich design that allows individual connection to all contacts on bottom plate. Switch deck is made up of 17 x 11 contacts in a rectangular arrangement over an area of 3 x 5 in. Prepunched



code card inserted into unit operates a trip mechanism to actuate desired contacts simultaneously. Self-cleaning, wiping-type contacts provide low contact resistance and long life. Switch permits manual operation if desired. Current rating is 10 amp. **Hickok Electrical Instrument Co.**, 10514 Dupont Ave., Cleveland 8, Ohio. F

Circle 670 on Page 19

Glow Lamp

high-brightness unit withstands shock and vibration

NE-51H high-brightness glow lamp can be adapted to many applications where high brightness is desirable. Said to be 20 times as bright as previous models, unit has a life in excess of 5000 hr when operated in series with recommended resistor. It withstands high-level shock and vibration. Lamp is intended for use as a pilot lamp on ac circuits only. For optimum performance on 110-125 v, resistor of 25,000 ohms is used in series with the lamp. Light output remains essentially constant throughout

Design High Pressure Fluid Systems up to 5000 psi. with Aeroquip Hose and Reusable Fittings

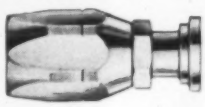
1509 Hose									1508 Hose			
4	6	8	12	16	20	24	32	Dash size (in 1/16")	6	8	12	16
1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	O.D. Tube Size	3/8	1/2	3/4	1
1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	Hose I.D.	3/8	1/2	3/4	1
1 1/16	27/32	31/32	1 1/4	1 5/16	2	2 1/4	2 3/4	Hose O.D.	27/32	1 5/16	1 1/4	1 5/16
5000	4000	3500	2250	1875	1625	1250	1125	Working psi.	5000	4000	3000	3000
20000	16000	14000	9000	7500	6500	5000	4500	Min. burst psi.	18000	16000	12000	10000
4	5	7	9 1/2	11	16	20	26	Min. bend radii	5	7	9 1/2	11

All dimensions in inches.

End Fittings Available

J.I.C. Swivel—1/4" to 2"

Male Pipe—1/4" to 2"



Split Flange ("O" Ring Shoulder)—1/2" to 2"

Elbows (45°&90°) —1/4" to 2", in swivel nut, split flange and standard 4-hole flange ends

AEROQUIP 1509 HOSE for high working pressures in temperature range from —40° F. to +200° F. Hose construction: seamless synthetic inner tube; double wire braid reinforcement; oil, mildew and abrasion resistant synthetic rubber cover.

AEROQUIP 1508 HOSE for very high pressure and high surge pressure systems, temperatures from —40° F. to +200° F. Hose construction: seamless inner tube; multiple spiral wrap reinforcement; oil, mildew and abrasion resistant rubber cover.

Use of flexible hose lines in the design of high pressure fluid systems can promote longer, trouble-free service life. This advantage is possible because flexible hose lines have the resiliency to withstand high surges, vibration and shock. These strains, occurring particularly in hydraulic systems, can cause early failure of rigid lines.

To meet all high pressure line requirements, Aeroquip offers two hose types: 1509 Hose with wire braid reinforcement and 1508 Hose with wire wrap reinforcement. Engineering tests conducted by Aeroquip show that the spiral wrap hose construction which is used in 1508 Hose gives longer service life in fluid systems subject to frequent or abnormal surge pressures.

The flexibility of Aeroquip Hose Lines permits quick and easy installation, even in confined spaces, without the forming and fitting required when using tubing or piping. In many cases, savings in installation time alone can pay cost of flexible hose lines used.

Aeroquip Hose Lines are unique in that every Aeroquip Fitting is detachable and reusable. In designing fluid systems, reusable fittings offer two advantages. First, mock-ups can be made and easily modified, using hand tools to assemble hose lines. Second, hose assemblies can be made up in production quantities from Aeroquip Bulk Hose and Reusable Fittings without expensive swaging machines in the manufacturer's plant. This benefit is also passed on to the equipment purchaser when replacement hose lines are needed. A small supply of bulk hose and a few spare fittings can be used to make replacements anywhere. Aeroquip maintains an extensive network of distributors to serve users of Aeroquip Hose Lines.

Complete catalog information and engineering assistance is available on Aeroquip 1509 and 1508 Hose Lines. A 16-page guide on planning and installing fluid systems with flexible hose lines is also available. Mail the coupon below for literature you desire.

Aeroquip Corporation MD-5
Jackson, Michigan

Please send a copy of

☐ "Guide for Routing and Installation of Aeroquip Flexible Hose Assemblies"

☐ Catalog 202

☐ Please have engineering rep call me

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STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

CONSTANT OUTPUT MOTOR ALTERNATOR NEEDS NO EXTERNAL REGULATORS. 600 watt 60 cps output is held at 117 v. ±5% with d-c input varying from 225 to 275 v. Supplies 60 cps for closed circuit TV and other communications and control devices in areas where only 250 v. d-c is normally available. Totally-enclosed, fan-cooled construction for hot, dusty locations; basic design adapted from the thousands of motor alternators which Safety Industries, Inc., has supplied for railway passenger cars throughout the world.

OPERATION FROM −60° TO +120° F -- that was just one of the many environmental conditions that Star-Kimble enginsers had to meet in designing a 400 cps, 3 kw output motor-generator for the Armed Services. Imperviousness to snow, rain, sleet, and wind-driven dust was also required. S-K met the specs with a special inductor type alternator having no slip rings, brushes or commutator, thus assuring adequate performance with minimum maintenance.

RUGGED, MOBILE AIR CONDITIONING SYSTEMS manufactured by Safety Industries as an outgrowth of extensive railroad air conditioning experience maintain critical control of temperature and humidity even when ambients vary over extreme ranges. Compact packaged air conditioning systems - 5 to 8 ton capacities - can be specially designed for controlling temperature and humidity in mobile or semi-permanent installations housing complex electronic equipment, such as used by the Armed Services. We invite your inquiry on close-control, self-contained air conditioning systems for your special applications.

Circle 502 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION
SAFETY INDUSTRIES, INC.
P. O. BOX 904 • TEL. UNiversity 5-3171 • NEW HAVEN 4, CONN.

PINTSCH COMPRESSING CORPORATION
ENTOLETER DIVISION
ELECTRICAL DIVISION

LIGHTING DIVISION
SAFETY RAILWAY SERVICE CORPORATION

AUTOMATIC TIMING & CONTROLS, INC.
THE HOWE SCALE COMPANY
SI HANDLING SYSTEMS

lamp life. Unit has maximum overall length of 1 3/16 in. **Miniature Lamp Dept., General Electric Co.,** Nela Park, Cleveland 12, Ohio. F

Circle 671 on Page 19

Phenolic Molding Compound

is sisal-filled, two-stage material

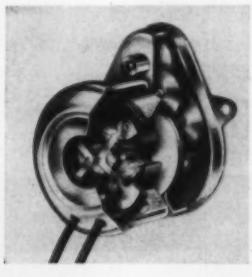
New impact phenolic molding compound, designated No. 18683, is a sisal-filled, two-stage compound in nodular form. It is designed for applications which require long flow, good water resistance, and glossy finish under low-pressure molding conditions. Parts molded from the compound are dimensionally stable, have impact strength of 1.4 ft-lb per in., and resist high humidity. Applications include textile pulleys, oil-well plugs, gas-meter housings, automotive-heater housings, terminal connectors, and electric-motor end bells. **Durez Plastics Div., Hooker Electrochemical Co.,** North Tonawanda, N. Y. F

Circle 672 on Page 19

Miniature DC Motor

is high-torque, low-current unit

Type 800 dc motor provides extended range of output speeds, high torque, low current drain, and excellent speed stability. Output speeds range from 900 rpm to 2 rpd with gear train, and from 960 to 3000 rpm without gear train,



One of the outstanding advantages of Townsend Tuff Tite fasteners is that they provide an economical means for leakproof joining of metal, asbestos, porcelain or plastic. The pre-assembled conical neoprene washers flow into the holes as the fasteners are seated, filling them and making waterproof seals. Tuff Tites are effective for any application requiring leakproof joints, such as those needed in the construction or appliance industries.

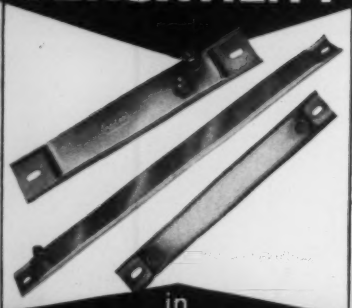
Tuff Tite advantages include ease and economy of installation, surface protection and vibration resistance. Standard items are immediately available from jobbers and warehouses. Tuff Tites are also available in numerous special designs to suit any application need.

If you are joining metal, plastic, porcelain or asbestos, you should know about Townsend Tuff Tites. Your Townsend representative will be glad to discuss them with you, or we will send you complete literature. Townsend Company, P. O. Box 237-E, New Brighton, Pa.

The Fastening Authority
Townsend
COMPANY • ESTABLISHED 1816
Sales Offices in Principal Cities
In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

Circle 503 on Page 19

Solve Your
HOT PROBLEMS
with
VULCAN
VERSATILITY



in
STRIP
HEATERS

Vulcan Electric Strip Heaters are especially designed for contact heating of dies, platens, molds, or any items with flat surfaces to which elements may be clamped; also as air heating source for ovens, air ducts, dryers, etc.

You have a wide choice of standard seamless one-piece sheaths — steel for sheath temperature to 750°F, Chromalloy for sheath temperatures to 1200°F; lengths — 8" to 42½" (or longer); wattage — 150 to 1500 watts (or higher); rugged non-oxidizing terminal posts.

When your hot problems call for *unusual* specifications, you get a speedy solution through *Vulcan Versatility* in engineering and production. Standard or special — Vulcan is ready to supply your complete needs in low-cost, efficient heating units — strip, cartridge, tubular, immersion, finned, band, and ring heaters. Send coupon for catalog and prices.

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DANVERS 6, MASS.

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

VULCAN ELECTRIC COMPANY
Danvers 6, Mass.

Please send catalog and price information on Vulcan Electric Heaters. I am especially interested in (check):

☐ Strip ☐ Tubular
☐ Immersion ☐ Finned
☐ Cartridge ☐ Other

NAME & TITLE.....
COMPANY.....
STREET & NO.....
CITY & STATE.....

Circle 504 on Page 19

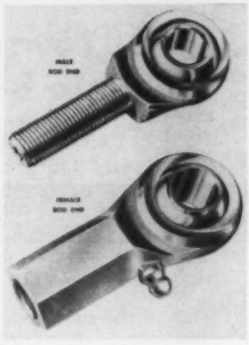
providing maximum torques of 30 and 0.6 oz-in. respectively. Current drain may be as low as 30 ma, depending on application. Voltage ratings range from 3 to 30 v dc. **Cramer Controls Corp.**, Centerbrook, Conn. B

Circle 673 on Page 19

Rod End

has lifetime lubrication

New rod end for commercial and industrial applications is of two-piece construction, with ball housing swaged around ball to provide large surface contact area between housing and ball. Standard housing and shank material is high-tensile, pearlitic, malleable iron. SAE-52100 alloy steel and sintered-steel balls are used. Ball-housing surface has



permanent, dry-film lubricant coat. Additional lubricant is supplied from sealed-in grease chamber, providing low coefficient of friction and sufficient lubrication for lifetime operation. Female and male types are available in standard bore sizes from ¼ to ¾ in. **Automation Bearings Corp.**, 120 Colonial Ave., Bridgeport 1, Conn. B

Circle 674 on Page 19

Nylon Stop Nut

locks, seals, and insulates

Brilok nylon stop nut is a self-tapping, hexagonal unit with locking, sealing, and insulating features. Nut locks at any position along shank of screw. As screw turns into resilient nylon, counter-compressive force builds up, giving a tight friction lock. Further tightening causes cone at base of nut to extrude into clearance spaces, forming an effective seal against

for truly
AUTOMATED
SPEED CONTROL

Where automation performance depends on accurate speed control.

Get mechanical drive accuracy and range with electrical control flexibility at lower cost.

Graham
most reliable variable speed drive made

Greater accuracy of speed setting and holding on open loop control — wider range and faster response for closed loop systems.

CONTROL SPEED in ADJUSTABLE PROPORTION to:

1. POTENTIOMETER SETTING or RECORDER SLIDEWIRE
2. .5 to 5 ma or any TRANSDUCER SIGNAL
3. 3 to 15 PSI AIR SIGNAL
4. PARALLEL BINARY SIGNAL from PUNCH CARDS, TAPES, COMPUTERS or BINARY TRANSDUCERS
5. VARIABLE FREQUENCY SIGNAL

- UNLIMITED SPEED RANGE
- UNMATCHED ACCURACY
- ULTIMATE SIMPLICITY and COMPACTNESS
- NO BELTS OR TUBES
- LOW COST

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE OR WRITE FOR COPY

ENTIRE UNIT EXPLOSION PROOF, if desired.

GRAHAM TRANSMISSIONS, INC.
DEPT. MD, MENOMONEE FALLS, WIS

Circle 505 on Page 19

Engineered by Tinnerman...

Train maker cuts assembly costs 37% with one-piece Tinnerman **SPEED CLIPS®**

On Lionel electric trains, one-piece Tinnerman SPEED CLIPS fasten car trucks to car bodies... cut assembly costs 37%. Each SPEED CLIP replaces a grooved screw-machine part and a special retainer ring. Also eliminated are riveting and crimping operations.

Specially engineered for Lionel, this SPEED CLIP is easily snapped through punched holes. Spring steel fingers compress, then spring apart to complete the truck-to-body attachment.

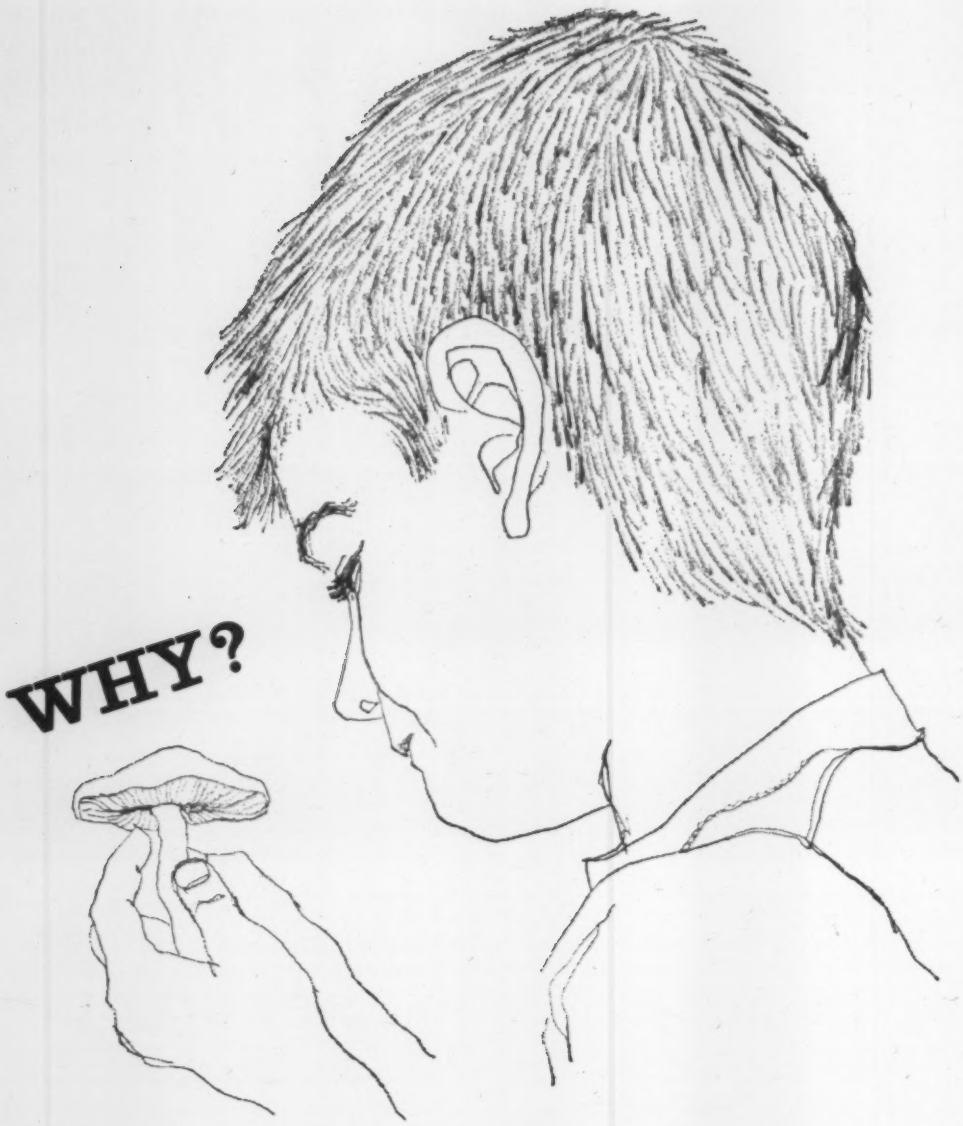
Perhaps your product can be assembled faster, better, at lower cost by a switch to Tinnerman SPEED NUT brand fasteners. Your Tinnerman sales engineer can make on-the-spot fastening recommendations. Or he can arrange for a complete no-obligation Tinnerman Fastening Analysis of your product. He's listed in the Yellow Pages under "Fasteners." Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.



YESTERDAY it wasn't there. Today, he picks it up and wonders: *why did it grow like that?* The miracle of growth! Whether it's a "toadstool" that springs up overnight or a cancer cell that suddenly comes into being, we've a lot to learn about the whole beautiful process of orderly growth . . . and the dreadful, senseless growth that is cancer.

The cancer puzzle is tied up in growth —growth of body cells smaller than the periods on this page.

Scientists, working under grants from the American Cancer Society, are ceaselessly studying cells—normal and cancer cells. And they too are asking: *Why?*

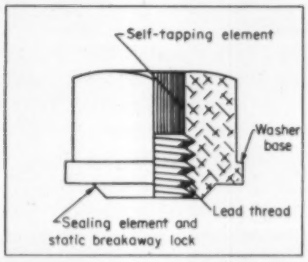
Why do cells suddenly change from normal growth to uncontrolled, disorderly growth? This question can be answered only by the most probing, painstaking and costly research.

Your contributions to the American Cancer Society will support hundreds of scientific studies necessary to save lives today and tomorrow.

Remember: Cancer can strike anyone. But you can strike back *hard* with your dollars. Send your gift to CANCER in care of your local post office.

AMERICAN CANCER SOCIETY

liquid or gas escape, or entrance of corrosive elements. Nut is used in all types of equipment where conditions require toughness, light weight, stability at high temperatures, abrasion resistance, corrosion



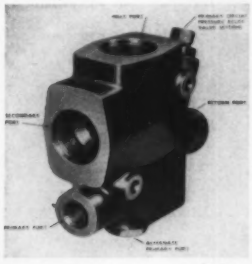
resistance, and strength in thin sections. Sizes range from No. 4 to ½ in. **Byrd Plastics Inc.**, 2953 W. 12th St., Erie, Pa. F

Circle 675 on Page 19

Flow Divider

has capacity of 60 gpm

FV 1126 flow divider supplies two hydraulic circuits from a single pump, permitting two simultaneous operations at different pressures from one pump. Designed to provide a large capacity at 2000-psi pressure in a small package, divider can be installed and piped in remote locations. Capacity of the unit



is 60 gpm, and size is 6½ x 5⅜ x 1½ in. Built-in relief valve is provided on constant-flow section. **Hydraulics Div., Webster Electric Co.**, 1900 Clark, Racine, Wis. K

Circle 676 on Page 19

Duplex Clutch-Brake

miniature unit has zero backlash

Model MBB duplex clutch-brake is available in four sizes in three shaft alternates. Characteristics include zero backlash, zero end play, no slip rings, and fast response. Servo

ADEL *Industrial Hydraulic Equipment*

for PEAK PERFORMANCE ADEL Hydraulic Valves and Pumps are setting new and ever higher standards for precision in manufacturing and efficient performance in operation. Following are but a few of the wide variety of models to meet all operating conditions.

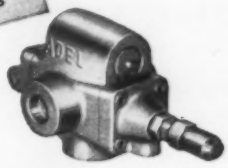
GEAR-TYPE HYDRAULIC PUMPS

For 1000 psi service with rated capacities at 1800 rpm of from 1.5 to 46.8 gpm.

DIRECTIONAL CONTROL VALVES

4-way valves with spring-centered, spring-offset, and 1, 2, or 3 position detent action. 1500 psi. Flows to 28 gpm.

BY-PASS VALVES



Relief, Sequence and Unloading valves. Direct or remote operation, 50 to 1500 psi range.

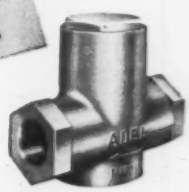
VOLUME (FLOW) CONTROL VALVES

Compensated type maintains constant flow over wide differential pressure range. No drain line required. 1500 psi.

PILOT VALVES

2 or 3 position detent. With or without dog or lever. Can be used as 4-way valve in small circuits. 1000 psi.

CHECK VALVES



Valves allow free flow in one direction only. Many variations available. 3000 psi.

Reliability ADEL PRECISION PRODUCTS

A DIVISION OF GENERAL METALS CORPORATION

HUNTINGTON, WEST VIRGINIA

Manufacturers of MARINE & INDUSTRIAL HYDRAULIC CONTROL EQUIPMENT

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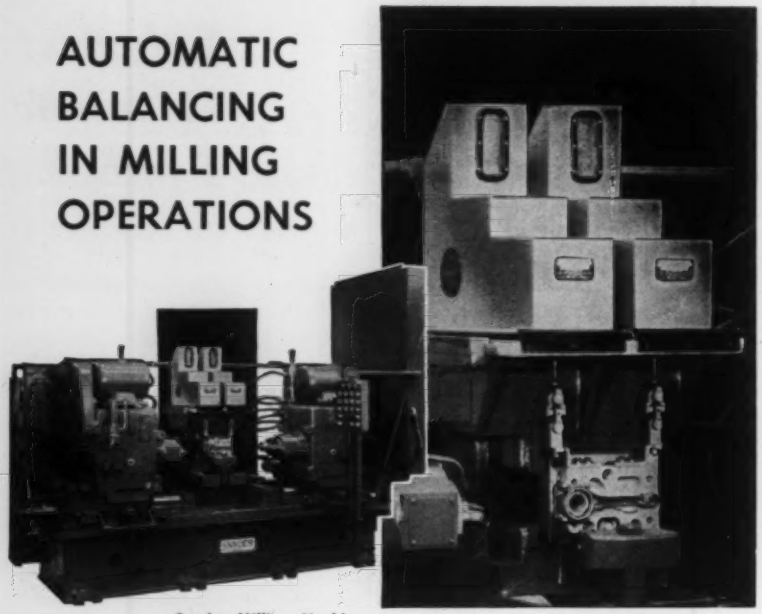
TEXAS
Air-Draulic Equipment Company
Houston, Texas

UTAH
Robert Taylor & Sons
Salt Lake City 10, Utah

WASHINGTON
Russ Chamberlin Company
Seattle, Washington

Circle 508 on Page 19

AUTOMATIC BALANCING IN MILLING OPERATIONS



Snyder Milling Machine

SHADOWGRAPH® SCALES

- determine weight distribution of connecting rods
- automatically set machine for correct stock removal

Perfect Balance in connecting rods is assured by utilizing two Shadograph Scales integrated with the Snyder Milling Machine shown above. Operation is entirely automatic.

The Shadographs, employing a new concept of precision scales, are especially designed to weigh both ends of the work piece. Weight distribution of each piece is registered by the Shadographs and signals are transmitted automatically to stations on either side. Balancing is accomplished by one-pass milling to tolerances of 1/16 ounce (1.7 grams) in either end or overall weight. Rods which do not meet maximum milling dimensions are rejected automatically.

Shadographs and other Exact Weight Scales are used in many types of automated machines including food packaging, meat slicing and plastics weigh feeders. Write for complete engineering data.

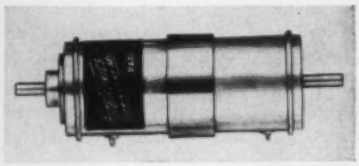
THE EXACT WEIGHT SCALE CO.
923 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

Exact Weight SCALES

Sales and Service Coast to Coast

Find us in your local "Yellow Pages"

BETTER QUALITY CONTROL . . . BETTER COST CONTROL



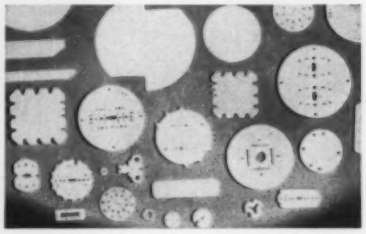
mounting diameters are 0.500, 0.750, 1.000, and 1.250 in., with corresponding minimum torque ratings of 3.5, 14, 32, and 56 oz-in. Designed for ac operation, unit also performs efficiently on full-wave rectified ac. Energizing clutch side of unit clutches input gear flange to output shaft, and de-energizing allows output shaft and input gear flange to run free. Energizing brake side of unit allows input gear flange to run free and brakes output shaft to housing. **Autotronics Inc.**, Box 812, Rte. 1, Florissant, Mo. I

Circle 677 on Page 19

Ceramic Parts

are as thin as 0.005 in.

AlSiMag alumina ceramic parts are now available in thicknesses as low as 0.005 in. Applications include use in electron tubes, microwave windows, transistor platforms, insulators for hearing aids, digital counter tubes, crystal cages, high-temperature relays, transformers, print-



ed circuits, fuses, and other devices. The ceramics have excellent strength, and resist high temperatures and frequencies. **American Lava Corp.**, Cherokee Blvd. & Mfgrs. Rd., Chattanooga 5, Tenn. A

Circle 678 on Page 19

Synthetic-Rubber Compound

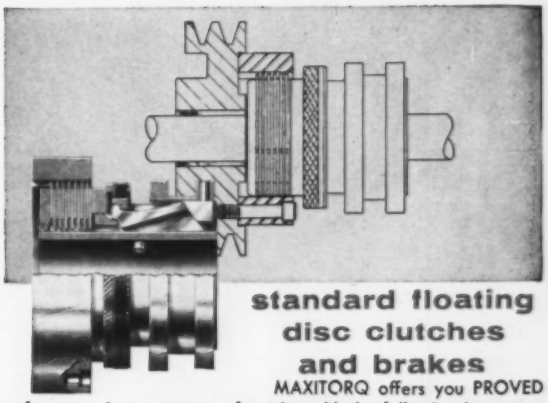
has excellent resistance to compression set

Compound 18007 resists attack and degradation by red fuming nitric acid. Material remained extremely flexible, retained better

if your design calls for CLUTCHES

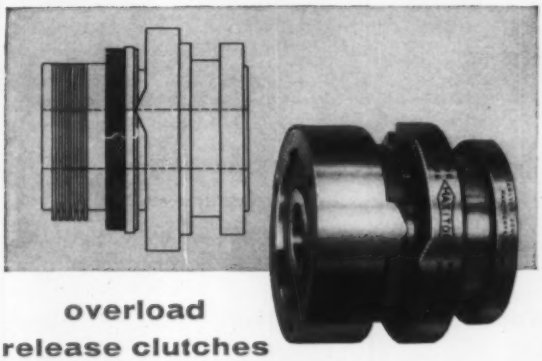
MAXITORQ electric clutches and brakes

PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Use easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V, A.C., rectified to 90 V, D.C. Other voltages on special order.



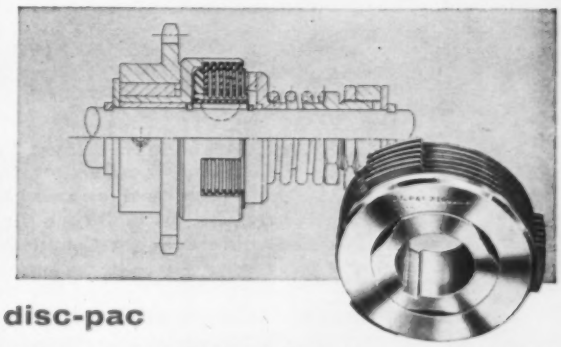
standard floating disc clutches and brakes

MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full power transmission . . . full range of sizes and types . . . supplied as complete, easily installed units.



overload release clutches

One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release on machines requiring this safety feature in addition to a clutch. Incorporate all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.



disc-pac

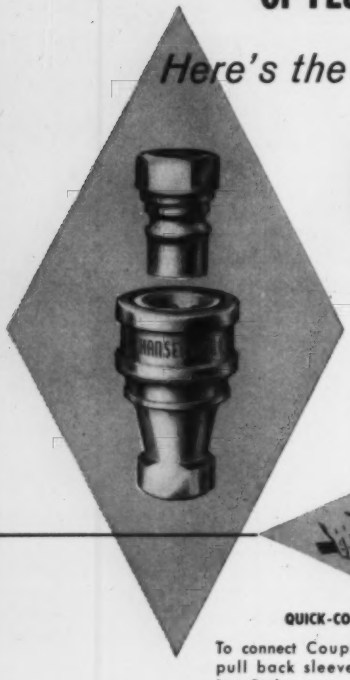
The "heart" of the SERVICE-PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

Write for complete data and specifications on any or all of the above. If you have a problem involving clutch applications, consult us. A letter or phone call will receive prompt attention. Dept. MD-5.

M THE CARLYLE JOHNSON MACHINE COMPANY, MANCHESTER, CONN.

WHEREVER YOU NEED 2-WAY SHUT-OFF OF FLUID LINE CIRCUITS...

Here's the Coupling for the Job



HANSEN

SERIES HK®

TWO-WAY SHUT-OFF COUPLING

QUICK-CONNECTION with INSTANT AUTOMATIC FLOW

To connect Coupling, merely pull back sleeve, push Plug into Socket.

Blue section shows how torpedo type valves open in both Socket and Plug to permit free flow of gas or liquid through connected Coupling.

QUICK-DISCONNECTION with INSTANT AUTOMATIC SHUT-OFF

shuts off both sides of circuit... prevents loss of liquid, gas, or pressure

To disconnect Coupling, just pull back sleeve on Socket. No tools required.

Blue section shows how torpedo type valves contact valve seats in both Socket and Plug to provide instant seal of fluid on both sides of circuit.

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for L. P. Gas, Steam, Oxygen, Acetylene, etc.

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both sides of the fluid line circuit—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

SINCE 1915

REPRESENTATIVES IN PRINCIPAL CITIES

QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 35, OHIO

Circle 511 on Page 19

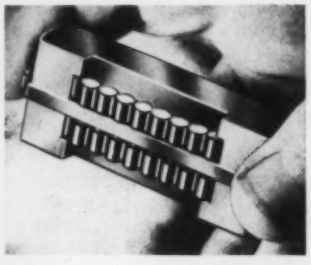
than average amount of elastic properties, and showed no flex cracking after two-week aging in this medium. Compound, which has excellent resistance to compression set, is recommended for testing and use in all rocket and missile applications which use red fuming nitric acid, and in other acid applications where standard synthetic materials are unsatisfactory. **Precision Rubber Products Corp.**, 3110 Oakridge Drive, Dayton 7, Ohio. G

Circle 679 on Page 19

Roller-Way Bearing

provides unlimited travel

New antifriction roller-way bearing eliminates stick-slip, reduces feed power, and eliminates roller skew, while providing unlimited travel



with constant accuracy. High unit capacity is assured through the use of 52100 steel in all load-bearing parts. Bearings are manufactured to close tolerances for use in precision machine tools. **Tycho Mfg. Co.**, 561 Hillgrove Ave., LaGrange, Ill. I

Circle 680 on Page 19

Flexible Insulation

for temperatures to 2000 F

Woven ceramic fiber tape, for wrapping and bonding around pipes as small as ½ in. diam with a zirconium-base cement, forms a positive, shock-resistant insulation that withstands temperatures to 2000 F. Insulation can be applied quickly and easily in restricted area. Second layer of ceramic tape, applied to complete wrap-around insulation, can be covered with spirally wound glass tape, and coated with a high-temperature varnish to provide effective protection against liquid impregnation. Tape is also available with two nickel-chrome

Three Layers of Forgings in 50-Ton Billet Container

This husky billet container, a product of Bethlehem's forge and machine shops, was recently completed after months of exacting work. It will be part of a 12,000-ton extrusion press designed and built by the Lombard Corporation, Youngstown, Ohio.

Though it looks like an ordinary one-piece forging, its appearance is deceptive. Actually, it's an assembly consisting of *three* cylindrical layers —an outer housing, an intermediate liner, and an inner liner. To get that one-piece effect, the most precise machining was required on the three components. Then came shrink-fitting—one of the touchiest steps of all—and later still, the finishing operations.

The container assembly as you see it here weighs 50⅔ tons. Its OD is 7 ft; ID, 32 in.; length, 6 ft 3 in. The two inner members are of chrome-molybdenum-vanadium-tungsten hot-work steel; the outer member is a chrome-molybdenum-vanadium steel.

Bethlehem facilities are always available for jobs of this nature, and we solicit your inquiries. We are especially well equipped to handle "unusual" orders, as well as the more conventional types. Remember, Bethlehem makes every kind of forging—large, medium, small—and offers precision machining that is unsurpassed anywhere.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

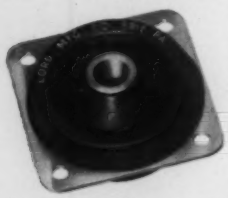
BETHLEHEM STEEL

Circle 512 on Page 19

SPECIFY LORD PRODUCTS

for engineered vibration and shock control

PLATE FORM MOUNTINGS

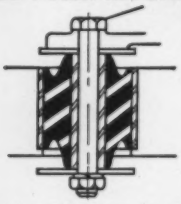


For controlling steady vibration plus occasional shock where excellent isolation characteristics are needed. Load ratings from ½ to 310 lbs./unit. Compact, one-piece construction . . . lightweight . . . easy to adapt and install.

TEMPROOF MOUNTINGS

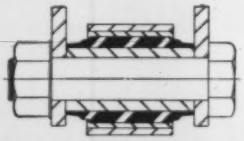
Developed to isolate vibrations on base-mounted equipment over temperature range from —80° to 250° F. Load ratings from ¼ to over 60 lbs./unit. Used on airborne electronic equipment.

TUBE FORM MOUNTINGS



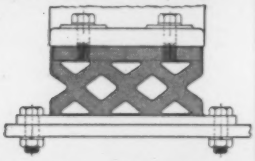
Designed to flexibly support motors, generators, compressors, engines with high lateral stability. Load ratings from ½ to 1500 lbs./unit. Rugged installation by clamping or press-fitting into socket.

DYNAFLEX® JOINTS



Rugged resilient bearings for use in pivot points on heavy-duty vehicles. Features: no lubrication, minimum wear, mounting and alignment accuracy, no close tolerances. Torsional deflections to ±30°; angular deflections to ±7°.

LATTICE MOUNTINGS

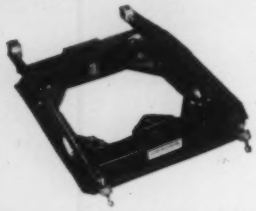


High deflection and low frequency vibration control mountings for machinery such as vibrating screens and conveyors, generators, food processing machinery and compressors.

FLEXIBLE COUPLINGS

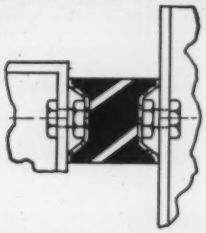
Custom-designed to provide smooth, shock-free power transmission, accommodate shaft misalignment, protect against overloads, reduce noise and vibration. No lubrication. Low maintenance. 1/80 to 3500 h.p. at 1750 r.p.m.

MOUNTING BASES



Complete, assembled special and standard bases for aircraft electronic equipment. Provide excellent vibration isolation. Interlocked mechanical parts for extra safety.

SHIPPING MOUNTINGS



For protection of packaged equipment (business machines, aircraft engines, electronic units, etc.) during shipment. Avoids damage, minimizes adjustments and repair at destination. Can be used many times.

OTHER LORD PRODUCTS

Missile Mounting Systems

Dynafocal® Aircraft Engine Suspensions

Center Bonded Automotive Engine Mountings

Meter Mountings

Friction Drive Wheels

Valve Seats

Bearing Seals

FIELD ENGINEERING OFFICES

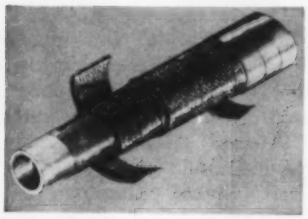
ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - MIchigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - BAldwin 4-8871
DETROIT, MICH. - TRinity 4-2060
KANSAS CITY, MO. - WEstport 1-0138
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - PEnnypacker 5-3559

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924



wire strands; when wrapped around pipe carrying metallic or radioactive fluids, it both insulates and sounds an alarm in the event of a leak. **Russell Mfg. Co.**, 630 E. Main St., Middletown, Conn. B

Circle 681 on Page 19

Miniature Capacitors

for low-voltage transistor applications

Slug-type miniature tantalytic capacitors are designed for low-voltage transistor applications, such as in hearing aids, where high microfarad values are required in extremely small spaces. They operate over temperature range of −20 to 50 C, and are rated from 1 to 20 v dc at capacitances from 0.1 to 16 mfd. Capacitors possess superior lead strength. Unetched tantalum (anode) lead is welded to solderable 13-mil nickel wire and completely sealed within Mylar sleeve with

epoxy resin. Cathode lead is formed by welding 13-mil nickel wire to silver case. Color code identifies electrical rating of each capacitor. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y. C

Circle 682 on Page 19

Flange-Type Collar

permits fastener use in oversize hole applications

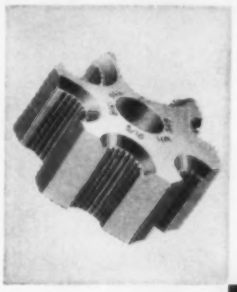
New flange-type collar, designated 3LC, is for use with Huckbolt fasteners. It permits use of fastener in oversize hole application, provides improved bearing in wood-to-metal,

GIVING YOU

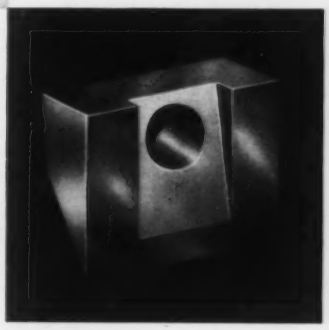
...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.



A competent group of Bunting Sales Engineers in the field and a fully staffed Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



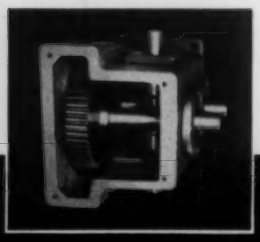
Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

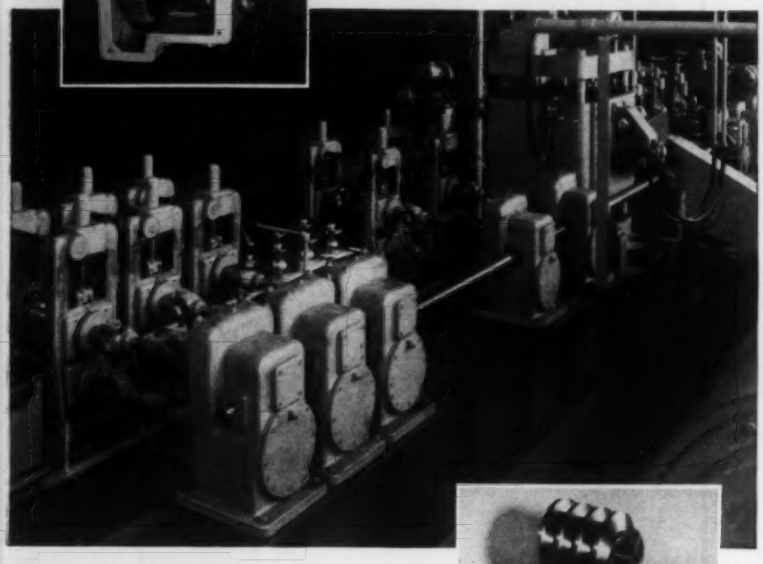
BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

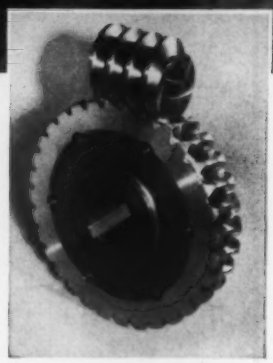
The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 514 on Page 19



Open view of drive unit shown below on machine.





Worm gearing provides exceptional load-carrying capacity in compact form.

Perfectly mated **H&S Worm and Gear** Sets insure smooth-running roll drives in *Abbey ETNA* tube mills

Custom-engineered mills bearing the Abbey ETNA name produce tubing and pipe around the world. Raw material passes through forming, welding, cooling, sizing and straightening processes. We're proud that Abbey ETNA selected Horsburgh & Scott precision worm and gear sets to drive the material flow regulating rolls.

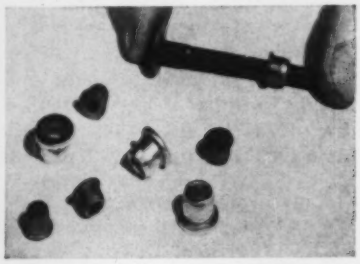
H&S worm gear sets range from 3-5/9:1 to 100:1, with center distances from 3" to 30". The H&S method of generating worm gear teeth to precisely the same tooth form as their mating worm guarantees smooth conjugate action and ability to carry heavy shock loads — with long service life.

Check with H&S on *any* gear requirements — worm, helical, herringbone, spur, bevel, mitre, internal or racks. Write for your copy of H&S Gear Catalog No. 57.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Circle 515 on Page 19

wood-to-rubber, and wood-to-fiber applications. Collar also eliminates tendency to overswage during installation, and prevents crushing, extruding, or deforming of surfaces being joined. Collar is available in 6061 aluminum alloy (bright finish), 6061-T67 aluminum alloy



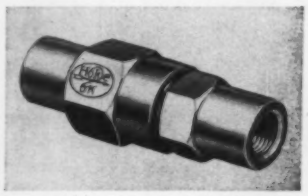
(dull finish), or C1006 mild steel. It covers a range of sizes for use with 3/16, 17/64, 5/16, 3/8, and 17/32-in. nominal pin diameters. Flange diameters for these sizes are 3/8, 1/2, 5/8, 3/4, and 1 in. respectively. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 683 on Page 19

Check Valves

piston-type units are for temperatures from −40 to 200 F

Series 570 piston-type check valves for liquid or gas service are available in brass or type 303 stainless steel. They range in size from 1/8 to 1/2-in. pipe thread, as well as 1/4-in. Swagelok and 37-deg JIC-type flare tubing connectors. Maximum operating pressure of brass



valve is 3000 psi, of stainless-steel unit, 5000 psi. Temperature range is −40 to 200 F. **Hoke Inc.**, 136 S. Dean St., Englewood, N. J. D

Circle 684 on Page 19

Adjustable-Speed Drive

is combined with right-angle gear reducer

Speed-Trol adjustable-speed drive combined with a right-angle gear reducer is suited for applications

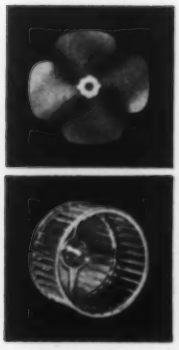
FULL COVERAGE

No matter which way the wind blows with your blower unit requirements—belt-driven, direct drive or radial-axial mixed flow—Torrington has the solution to your problems.

This means complete technical data and the proved-out performance rating on three lines of basic blower unit designs.

In addition to the standard direct drive units and the already famous VariBasic belt driven series, latest and most spectacular addition is the exclusive Radiax unit, combining the optimum performance characteristics of both radial and axial flow techniques.

The result is FULL COVERAGE—the best "problem insurance" you could have.
Talk to Torrington!

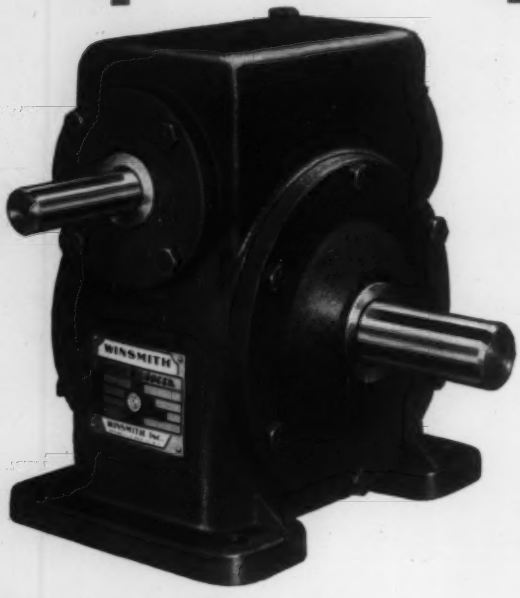


THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 516 on Page 19

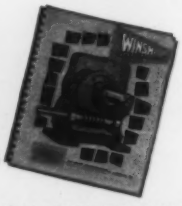
all the way up to 34 hp!



Winsmith worm gear speed reducers

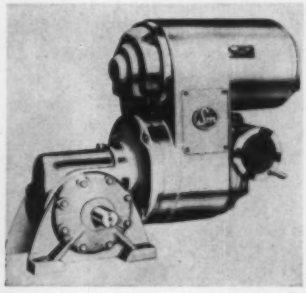
For top performance on your big jobs, Winsmith Worm Gear Speed Reducers are available for any application up to 34 horsepower. Compact, efficient, economical — with endurance to spare — Winsmith Speed Reducers offer you the most complete line of standard models, sizes and drive arrangements from a single source. For speed reducer requirements all the way down to 1/100 hp, you'll find it pays to specify Winsmith.

WINSMITH SPEED REDUCERS



WRITE TODAY FOR CATALOG NO. 155 for useful information on selection, operation and maintenance of the hundreds of sizes and types of Winsmith Speed Reducers.

WINSMITH, INC. 16 Elton Street., Springville, (Erie County), N. Y.



where output shaft must be at right angles to transmission. Unit, with positive pulley construction, provides infinitely adjustable speed and accurate maintenance of speed. Right-angle gears transmit power smoothly and quietly. Positive oil seals on both input and output shaft of reducer permit units to be operated horizontally or vertically without oil leakage. Motors with right-angle gears are available in drip-proof and totally enclosed construction, in speeds from 5.5 to 360 rpm and speed variations from 2:1 to 10:1. **Sterling Electric Motors Inc.**, 5401 Telegraph Rd., Los Angeles 22, Calif. L

Circle 685 on Page 19

Preplated Steel

is low cost, utility grade

C-grade steel, available in preplated finishes of chrome, nickel, and copper on a steel base, has a wide range of applications for trim and functional parts. Material requires no cleaning, plating, or polishing, and is adaptable to standard production techniques without damage to finish. Product is available in sheets of 24 x 96 in. and up to 160 in., coils of $\frac{1}{8}$ to 24 in. wide, and flat strips $\frac{1}{4}$ in. or wider, up to 96 in. long. Gages range from 0.008 to 0.036 in. **American Nickeloid Co.**, Peru, Ill. I

Circle 686 on Page 19

Enclosed Switches

have one-piece molded neoprene insulator-seal

Redesigned E6 and V6 general-purpose switches feature a compact enclosure that provides for easy installation. Design exposes inside switch terminals for easy wire connection by separating enclosure in-

Does specialized business publication advertising help salesmen?

No one is in a better position to give a hard-boiled, practical answer to this question than the men who spend their working lives on the sales front... the men the ads are supposed to help... the men who sell.

Here is the statement of a salesman who knows what advertising does for him when it appears in the industrial, trade or professional publications that serve the specialized markets to which he sells:

W. A. Beach
Black & Decker Mfg. Co.
sells to wholesalers and retailers

says Mr. Beach:

"We have to sell our product first to the wholesaler; then help him sell to the retailer. We do a lot of missionary work. We make calls with the wholesaler salesmen and we run dealer and clerk training clinics in which we try to help the dealers improve their merchandising.

"Our trade advertising in publications read by the wholesaler and dealer, works with us along those same lines. In other words, it's like having an additional sales representative in each territory constantly calling on the dealers and wholesalers. Every time they open their trade books he tells them about our products and the special promotions we run to help them sell more. He works nights too, and calls on them at home when they're doing their reference work and planning. I know they do take their magazines home at night and read them. So, in effect, this 'salesman' works at night for us, and I do believe he finds them in a more receptive mood at that time.

"The greatest evidence that our advertising is out there doing a job and really paying off is in connection with the two large-scale promotions we do each year.

"For instance, right now we're working on our current Christmas promotion called 'The Bell-Ringer'. That was announced in September. Between the announcement and the Christmas selling season we must sell the wholesaler and then set up a schedule with each wholesaler to go out with his men and call on the trade and actually sell the deal to the retailer. You can imagine how tight our schedule is. In this short span of time we have to call on practically every hardware dealer in the territory. It adds up to a terrific number of calls and in order to get around, we just can't afford to give each dealer all the time we'd like to. In addition, it's extremely difficult to explain all the details on something like this Christmas promotion in the short time allotted each dealer.

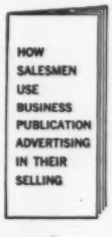
"We couldn't do it if the advertising wasn't in there doing part of the work for us. Believe me, it's wonderful to find that when you do call on a wholesaler or dealer you don't have to take the time to explain all the details, because he has already read about it in the hardware publications. In most cases he's ready to see the merchandise. We have the opportunity to close the sale in short order. Right now I'm engaged in making dealer calls with wholesalers' salesmen and I'd say that nine cases out of ten the dealers have already seen our ads on the Christmas promotion and are somewhat pre-sold on the deal. In fact, in most cases I've found that all I have to do is show him the merchandise."

Ask your own salesmen

what your company's business publication advertising does for them. If their answers are generally favorable, you can be sure that it is really helping them sell. If too many answers are negative, it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' business publication advertising.



You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.

NBP

...each of which serves a specialized market in a specific industry, trade or profession.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 11E
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Business Publication Advertising in Their Selling."

Name _____

Title _____

Company _____

Street Address _____

City _____ Zone _____ State _____

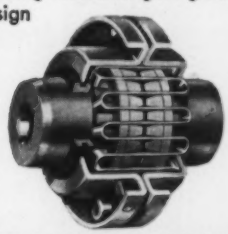
How one FALK coupling saved more than $1,000 per month

Pictured below is a Falk Steelflex Coupling assembly which connects a 2500 hp motor to a reduction unit driving an 18" bar mill in a Midwestern steel plant. This coupling replaced another type which broke repeatedly, causing maintenance expense averaging $1,000 a month—plus costly production losses. Since installation of the Falk Coupling, with its controlled torque mechanism that disengages when a predetermined overload occurs, there has been no interruption of production. Savings in maintenance and in lost production time are well in excess of $1,000 per month...dramatic proof of the importance of coupling design!

Long coupling life is not the sole criterion of coupling performance. Inadequate shaft couplings may be the cause of bearing damage or shaft breakage on your machines. If so, a change to Falk Steelflex will give two-fold protection to your connected machines: (1) compensation for reasonable degrees of shaft misalignment, and (2) torsional resiliency to reduce peak loads as much as 30%. These advantages are as important to you as the long service life of the Falk Steelflex Coupling itself.

Falk Steelflex Couplings, in types and sizes to meet virtually all industrial applications, are promptly available from distributor, warehouse and factory stocks. Consult your Falk Representative or Authorized Falk Distributor.

Basic **Type F**—cutaway view showing exclusive grid-groove design



THE FALK STEELFLEX ...a truly flexible coupling

Here is the coupling that has all the strength of steel, yet is truly flexible. More *than a million* have been bought for industrial service of many kinds.

Because, in addition to its inherent superiorities of design, the Type F Steelflex can be used horizontally or vertically without modification or special parts, it has been adopted as standard in many plants—and by many designers and manufacturers of industrial equipment...Write for Bulletin 4100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in many principal cities

Circle 519 on Page 19

Good couplings not only connect machines; they prolong machine life and boost production!

FALK

...a good name in industry

to two halves. One-piece molded neoprene insulator-seal is cemented permanently into bottom half of enclosure. Switches incorporate a rugged housing and hex-shaped conduit hub. Enclosure is available in five different integral actuator designs and in side or bottom-mounted

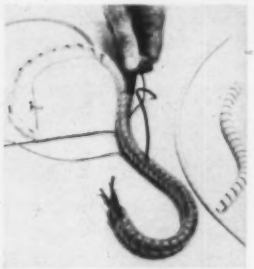
types. Standard units have single-pole, double-throw contact arrangement. Electrical rating is 15 amp, 125, 250, or 460 v ac; ½ amp, 125 v dc; ¼ amp, 250 v dc. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 687 on Page 19

Cable Wrap

for high-temperature use

New Heli-Tube cable wrap now has softening point of 275 F with no sacrifice of springlike quality. It is a spirally-cut, smooth polyethylene tubing useful for binding electrical wires into cable with full flexibility for wire lead-offs at any



point. Tubing is available in ⅛, ¼, and ½-in. diam for bundles of ½, 1¾, and 1½ in. respectively. **M. M. Newman Co.**, Marblehead, Mass. B

Circle 688 on Page 19

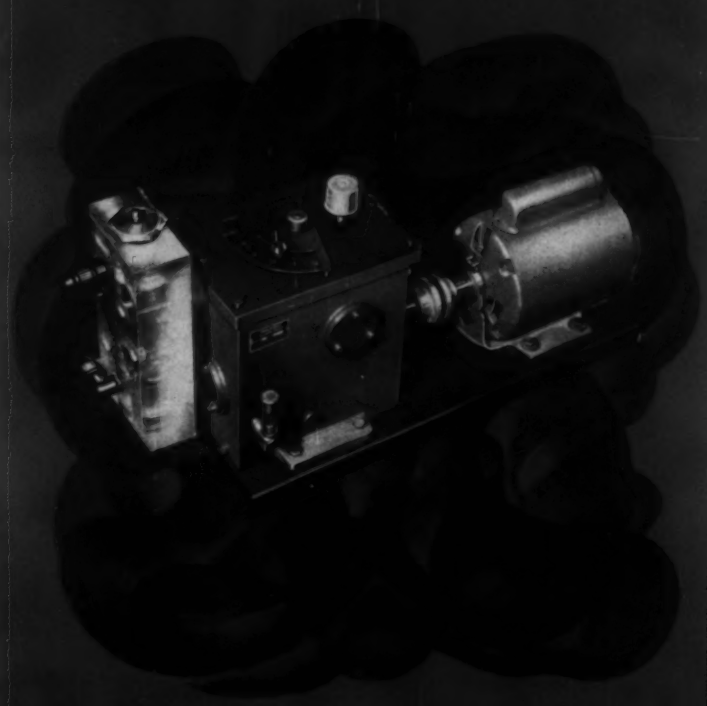
Gate Valves

in sizes from ½ to 2 in. are of forged steel

Line of forged-steel gate valves incorporates bolted-bonnet design, with outside-screw rising stem, solid-

MANZEL

gives you constant-mix slurry pumping



NO SLURRY SETTLING with Manzel's new SP-90 Slurry Pump! Exclusive feature permits proportion of slurries to remain constant in mix tank . . . while pumping rates are variable from maximum to 1/5 of maximum. Your Manzel field engineer will give you full details.

FREE CATALOGS: Write for complete catalog on Manzel Slurry Pumps and Chemical Feeders, giving details of construction, performance, applications.

Manzel

776 Babcock Street • Buffalo 10, New York

Specialists in metering pumps and lubricators since 1898

Circle 520 on Page 19

Here's the **NEW** variable-speed, explosion-proof Model 16AM

GAST rotary vane AIR MOTOR

Newest and largest Air Motor in the Gast line, this Model 16AM may solve an original equipment (or plant use) problem for you! It's compact — only 14⅜" x 8" x 7⅝" high. It's light in weight — only 65 pounds. It delivers up to 7 h.p. with good torque characteristics.

Listing at $200, it offers unique advantages for driving equipment located near a compressed air source:

1. Speed infinitely variable from 300 to 2,000 r.p.m. with any simple air valve control. Air motors always run cool.
2. Explosion-proof design, safe in explosive atmospheres.
3. Can't burn out from overloads — stalling doesn't harm it.
4. Heavy-duty construction with ball bearings, dual seals.
5. Six vanes in rotor automatically take up their own wear for constant high efficiency and long life.

Designed to operate on air pressures from 30 to 90 p.s.i., Model 16AM is suitable for driving direct, through gear box or pulley. Foot (base) is standard. End plate also has four tapped holes for flange mounting to gear box or other driven unit.

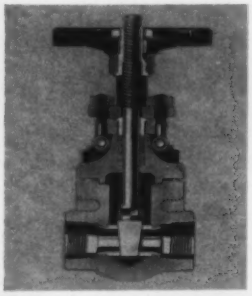
Perhaps you can use air power on a hoist, fan, pump, mixer or other product. Write today for new Bulletin 16AM.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY
- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"



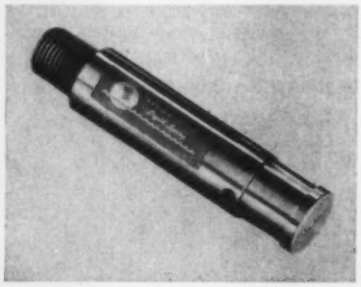
wedge disc, and rolled-in seat rings. Valves are available with screwed or socket-welding ends in sizes from ½ to 2 in. They are rated 800 lb at 850 F, and 2000 lb at 100 F. **Lunkenheimer Co.**, P. O. Box 360, Annex Station, Cincinnati, Ohio. G

Circle 689 on Page 19

Liquid-Spring Damper

has 1-sec time delay

New liquid-spring Shok, using liquid compressibility, has a time delay of 1 sec. Standard model can be modified to provide time-delay return from 1 sec to ½ hr on a ½-in. stroke by absorbing 98 per cent of input energy. Damper is available with adjustable energy ab-



sorption rates, and in sizes up to 44,000 lb-in. energy absorption with up to 2-in. strokes. Any mounting arrangement and input velocity can be built into the unit. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y. F

Circle 690 on Page 19

Cam Followers

are nylon-sealed units

New nylon-sealed cam followers have minimum friction, and eliminate infiltration of dust, powder, or other abrasives. They are made with no envelope dimensional

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LUBRICATING DEVICES

LUBRIKIT... An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

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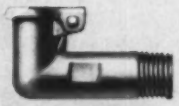
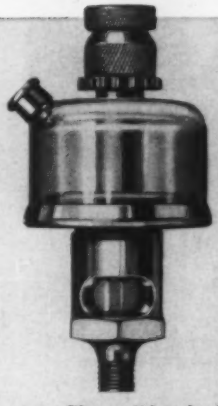


Style L — No. 1204
Brass Elbow (Threaded)

SIGHT GRAVITY FEED OILERS

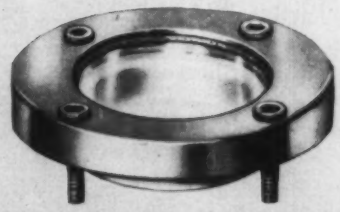


Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

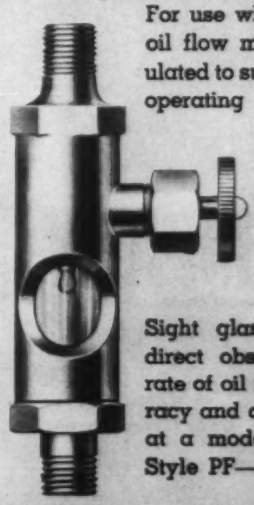
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

The Standard For Industry For Almost Half A Century

1868-C South Kilbourn Avenue
Chicago 23, Illinois

Clip this page for handy "rough reference"

Circle 522 on Page 19

NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

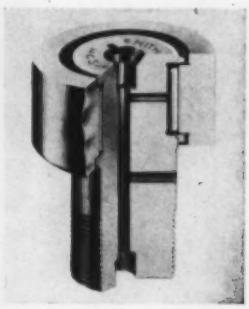
COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

Circle 523 on Page 19



change from standard types. Unit shown is Type HCS for heavy-duty applications. **Smith Bearing Co. Inc.**, P. O. Box 1119, Station D, Trenton, N. J. E

Circle 691 on Page 19

Liquid-Level Controls

for use in conductive liquids with resistances to 20,000 ohms

New two and three-pole, floatless, electrode-type liquid-level controls are suitable for use in conductive liquids, such as water, acids, and alkalies, where resistance does not exceed 20,000 ohms. Control is energized from an ac source, draws 2 w open circuited and less than 5 w closed circuited, and is adaptable for electrical lock-in or lock-out. All terminals are stud type, situated on a single molded panel on front of control, providing acces-

sibility during wiring. Contacts are double-break, bridge type, and utilize ¼-in. diam fine silver buttons. **Charles F. Warrick Co.**, 1964 W. Eleven Mile Rd., Berkley, Mich. H

Circle 692 on Page 19

Nylon Flare Nuts

for polyamide tubing provide tight seal

Polypenco nylon flare nuts provide a tight seal and can be temperature cycled up to 300 F without leaking. They resist loosening by vibration

and will not shear plastic tubings when overtorqued. Nuts are suited for sealing nylon pressure tubing to a metallic flare body. They are standard SAE 45-deg flare recommended for use in systems with maximum pressure of 250 psi. Resilient nuts yield under tension in area of pressure on flare, providing

form gripping action to compensate for flow tendencies of tubing on temperature cycling. Nuts are available in 1/8, 3/16, 1/4, 5/16, and 3/8-in. sizes. **Polymer Corp. of Pennsylvania**, 2140 Fairmont Ave., Reading, Pa. C

Circle 693 on Page 19

Silicone Rubber Tapes

have high oil and water resistance

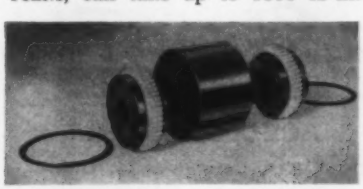
Silicone-rubber-coated Novabestos sheets and tapes, designed for use as primary and secondary insulation in power cables, have excellent resistance to dry baking heat and good oil and moisture resistance. They withstand greater shock vibration and abuse than glass-cloth-base tapes, and the insulation stays together after severe flame exposure. Style 7526 is supported with parallel strands of glass yarn which provide unidirectional tensile strength of 75 lb per in. width. Style 7527 is reinforced with a glass scrim, providing lengthwise tensile strength of 75 lb and crosswise tensile strength of 50 lb per in. width. **Asbestos Textile Div., Raybestos-Manhattan Inc.**, Manheim, Pa. C

Circle 694 on Page 19

Gear Coupling

has interchangeable bushings

New gear coupling, designated 162M, can take up to 1800 lb-in.



FOOTE BROS. **Motorized Drives**

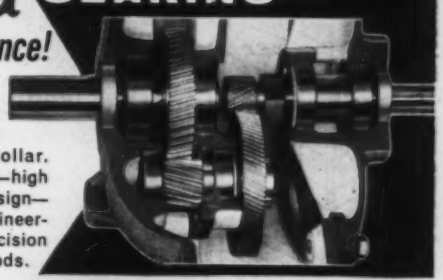
Duti-Rated **LIFETIME GEARING**

Gives You More Power Per Dollar

Duti-Rated **GEARING**

Makes the Difference!

Duti-Rated Gearing is the heart of Foote Bros. Motorized Drives ... drives that give you more load capacity and wear life per dollar. This is premium quality gearing—high hardness, accurate, balanced design—the product of thousands of engineering and development hours, precision tooling and manufacturing methods.



FOOTE BROS.

Line-O-Motor

Write for CATALOG MRA. It has complete details and selection data on Foote Bros. Motorized Drives.

this trademark stands for the finest industrial gearing made

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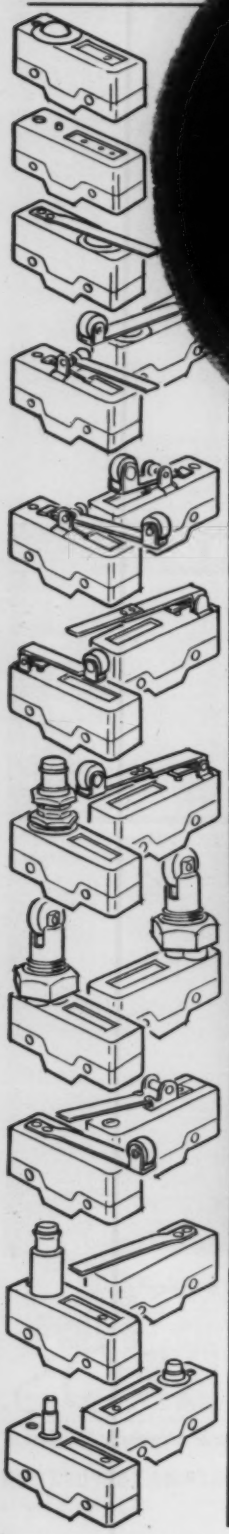
Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 South Western Boulevard Chicago 9, Illinois

19
ACRO
Actuator Styles



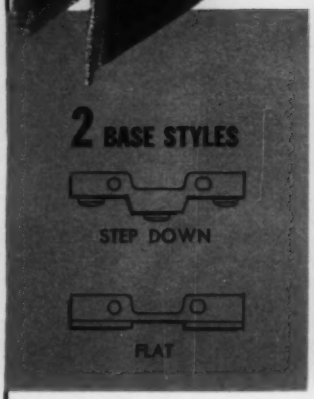
Now more than ever . . . America's No. 1 Basic Switch!

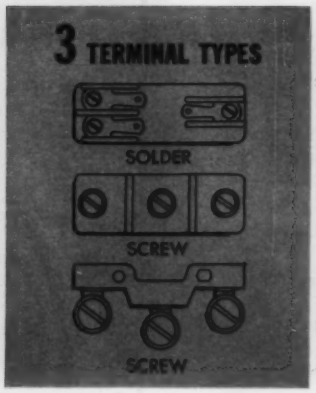
NEW 20-AMP Capacity

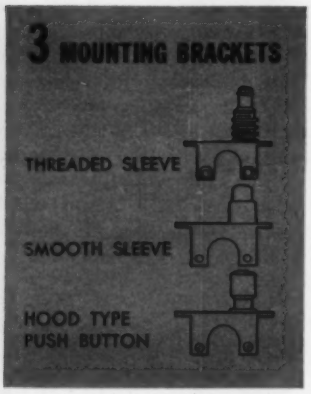
ACRO BASIC SWITCH

The ACRO Basic Switch now gives coverage of an even wider range of requirements. New extra-high capacity model, conservatively rated at 20 amps, incorporates a new type of rolling spring—the switch principle made famous by ACRO—and a higher contact pressure. In the same compact basic enclosure, you can get literally *any* combination of capacity, actuator, base style, terminals and mounting brackets . . . plus a wide range of operating pressures and contact gaps. The adaptability of ACRO Basic Switches to your designs is unmatched!

Write for new 8-page catalog.







ACRO BASIC SWITCH SPECIFICATIONS:

Operating force: 20 oz. maximum
Enclosure size: 1 15/16" x 11/16" x 29/32"
Contact gap: .010 to .030
Capacity: 20 amps, 2 hp, 230 volts A.C.

Mr. Controls

Robertshaw-Fulton
CONTROLS COMPANY

ACRO DIVISION
Dept. 335, Columbus 16, Ohio

Circle 525 on Page 19

torque. Since stress-relieved, injection-molded nylon gears are used, no lubrication is needed. Gears, held in place on steel hubs by spring rings, make a smooth, resilient contact with steel sleeve. Interchangeable bushings are available for shaft sizes from ½ to 1⅝ in. Coupling weighs only 6½ lb and fits on short shaft extensions. **John Waldron Corp.**, P. O. Box 791, New Brunswick, N. J. D

Circle 695 on Page 19

Speed Governor

for permanent-magnet motors

New speed governor for Globe permanent-magnet, 1¼-in. OD, dc motors provides two regulated speeds within speed capacity of motor with which it is used (generally about 4000 to 15,000 rpm). Each speed

can be set by a separate adjusting screw. Governor uses two pairs of vibrating contacts to control to the adjusted speed. Motor is normally furnished with three leads, one for negative connection and the remaining two for speed. Switching from low to high speed is accomplished by connecting high-speed circuit to low-speed circuit. Motor can be reversed by reversing polarity of applied voltage. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 696 on Page 19

Plastic Switches

are 10-amp, snap-action units

Series 5200 plastic switches are for military and industrial applications where activating mechanisms move slowly, as in thermostatic or pressure elements. Manufactured of dimensionally stable plastic, the 10-amp, snap-action units are available

DESIGNERS AND ENGINEERS!

Self-Lubricating Morganite solves today's critical design problems!

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Insure trouble-free operation in continuous service in high temperatures and pressures, oil, corrosive acids, gases, grease and grime. Morganite components "step-up" efficiency, reduce failures and machine down-time. Install application-tested MORGANITE components for better performance on aircraft and industrial fuel pumps, meters, food and processing equipment, jet engine pumps, radar equipment, conveyors, compressors, sealed mechanisms and wherever lubrication is a problem. Engineering bulletins on typical applications available on request.

CALL OR WRITE now, for complete information or recommendations on your specific applications. Morganite engineers will gladly assist in working out your problems.

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Drum Controller Contact

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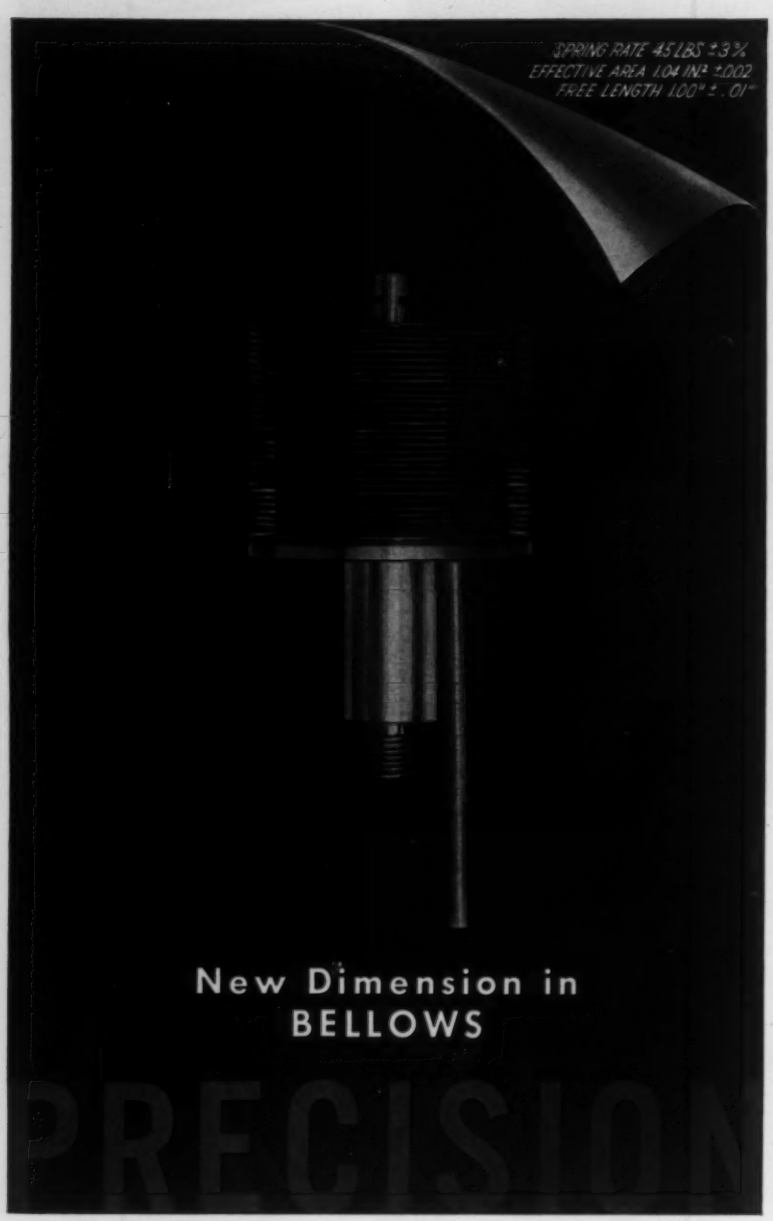
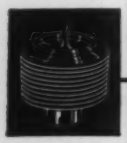
Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts.
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 526 on Page 19



When your specifications for design and manufacture of precision bellows require unusual know-how or close scheduling, Belfab Corporation may be your best source. Precision welded bellows by Belfab have helped solve many "impossible" problems—and almost literally helped develop new dimensions in bellows precision.

Preliminary designs, catalog and data sheets furnished on request without obligation.



THE BELFAB CORPORATION

AGAWAM, MASSACHUSETTS • DAYTONA BEACH, FLORIDA

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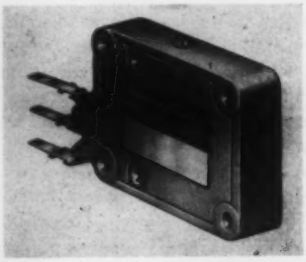


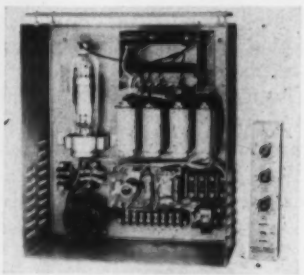
with actuating button in either center or off-center position. Off-center switch is for use where lower operating forces and greater travel are required. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn. B

Circle 697 on Page 19

Motor Controller

for ¾-hp shunt-wound motor

C60 electronic motor controller operates a ¾-hp shunt-wound motor on 220-330 v, 50-60 cycles, single phase. Motor speed is from 0 to 2400 rpm, with full torque from 300 to 2400 rpm. Controller incorporates acceleration control, reverse, and coarse and fine speed adjustment. Controller is mounted in a steel cabinet measuring 14 x 16 x 6 in. Control station components are mounted in a 2 x 2 x 9-in. steel box connected to controller by a 10-ft vinyl jacketed cable. Mo-



tor can be started and stopped, reversed, and speed changed from control station. **Gerald K. Heller Co.**, 1819 Industrial Rd., Las Vegas, Nev. L

Circle 698 on Page 19

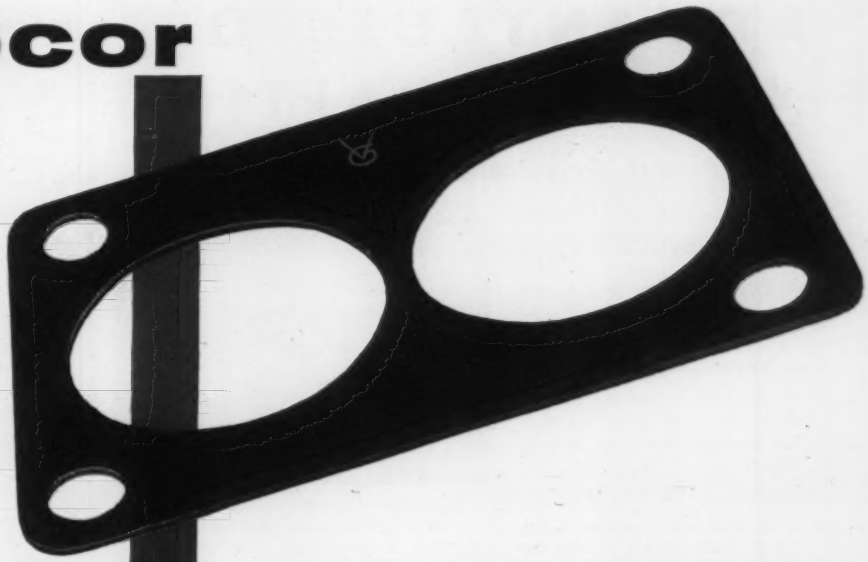
Miniature Thermostat

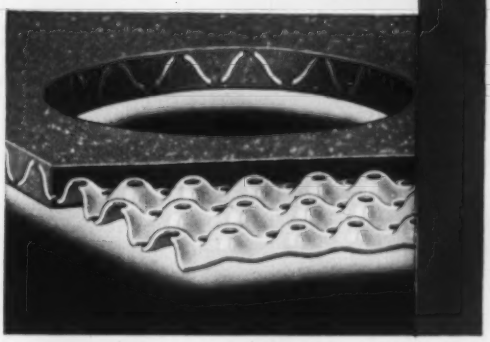
has inherent sensitivity of less than 1 F

Miniature Thermoswitch unit is useful in applications, such as crystal or transistor ovens, where pre-

Victocor

new super-sealing gasket material





Cross section of **Victocor.** Thin steel core is die-formed with continuous projections alternating in each face. (Type 200 core has 800 projections per sq. in.) Sealing element layers, top and bottom, are bonded simultaneously with core into integral structure. Deep penetration of core projections increases stability and heat conductivity.

TYPICAL PHYSICAL PROPERTIES — TYPE 200

Thickness	.030/.035" min.
% Compressibility at 1000 psi.	*10-15
% Recovery at 1000 psi.	35 min.
% Compressibility at 5000 psi.	*16-21
% Recovery at 5000 psi.	30 min.
Service temperature	750 deg. F.
Crush resistance psi.	100,000
Corrosion resistance against aluminum, magnesium, steel and copper	Good

*Slightly higher values are obtained with heavier gauge.

. . . where you need these maximum characteristics

- low torque loss
- high heat resistance
- high crush resistance
- high dimensional stability
- thin construction— .030/.035 gauge

Victocor justifies re-examination of your most exacting sealing specifications. It's a totally new product—offers more in every desirable heavy-duty characteristic.

Victocor was developed particularly for high-flange-pressure applications. Its steel core construction accelerates heat conductivity. It is strong and highly flexible.

Resistance to hot oils, gasoline and water is excellent, and **Victocor** positively retains all commonly used coolants.

Victocor's sealing element—a special asbestos-elastomeric compound—is extremely resilient. It helps compensate for mating surface irregularities. No coating is required when installing **Victocor** gaskets, and they're easily removed for replacement.

4 Standard Types Available—Test Samples Free

Where can you seal better and more economically with **Victocor?** Let Victor engineers help you decide. It's available in four standard types and many modified combinations. Meanwhile, write for complete technical data and free test samples. Please mention proposed application. Address the factory, or contact your Victor field engineer.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.
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VICTOR

Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 528 on Page 19

(Advertisement)

ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by

C. Hotchkiss, Jr.

Application Engineer

Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼-inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

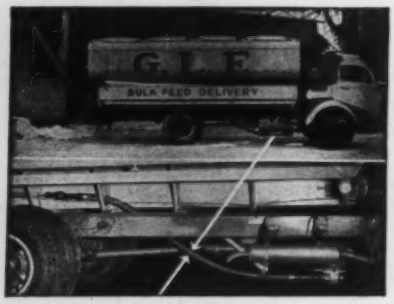


Fig. 1

Relative Motion — Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾-inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Co.

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

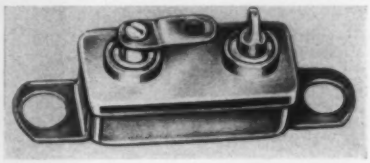
Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛-inch to 1¼-inches; for remote control applications in diameter sizes from ⅛-inch to 1⅝-inches. The 1¼-inch power drive shaft will transmit up to 10 HP while the 1⅝-inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering bulletin 570.

STOW MANUFACTURING COMPANY

11 SHEAR STREET • BINGHAMTON, NEW YORK

cise temperature control is necessary to insure consistent performance in widely different environments. Unit, which operates by differential expansion of metals, has an inherent sensitivity of less than 1 F. Operating-temperature limits are −65 to 220 F, and switch can be adjusted over −20 to 200 F



range. Soft-solder sealing of adjusting screw permits setting to be made without destroying hermetic seal. Unit resists 10-g acceleration at 500 cps. **Fenwal Inc.**, Pleasant Street, Ashland, Mass. B

Circle 699 on Page 19

Corrosion-Resistant Alloys

in clad-plate form

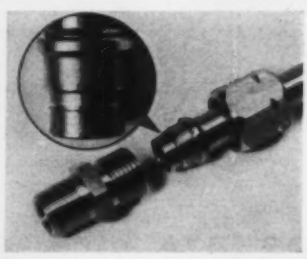
Hastelloy B, Hastelloy F, Hastelloy C, and titanium corrosion-resistant alloys have now been rolled in clad-plate form. Applications include use in the chemical, petroleum, and petrochemical industries where corrosion is a major problem. **Lukens Steel Co.**, Coatesville, Pa. C

Circle 700 on Page 19

Tube Fitting

has good corrosion resistance and high pressure capacity

Stainless-steel "bite-type" tube fitting incorporates a new ferrule which provides both adequate corrosion resistance and high pressure capacity. Ferulok fitting requires no flaring of tube, but depends on a grip produced when fitting nut is tightened, causing ferrule to cut into outer surface of tubing. New ferrule, designated SS30, satisfactorily resists chemical action of 10 per cent phos-



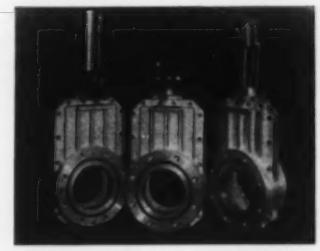
phoric acid at 200 F and boiling 10 per cent citric acid. Inset shows tube end with ferrule forced back, revealing the bite which gives fitting its grip. **Fittings & Hose Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 701 on Page 19

Gate-Type Valves

can be installed in any position

Gate-type, high-vacuum valves have full-opening design with straight-through unrestricted flow and short flow path to provide maximum conductance. Valves, which are ST series, can be installed in any position and sealed vacuum tight against atmospheric pressure in either direction. Three types of actuation are available: pneumatic (left), handwheel (center), and



quick-acting toggle lever (right). Air-operated valves require 65 psi pressure for operation against atmospheric pressure, and 50 psi for normal operating conditions. Valves are available in 2, 3, 4, and 6-in. sizes. **F. J. Stokes Corp.**, 5500 Tabor Rd., Philadelphia 20, Pa. E

Circle 702 on Page 19

Flexible Coupling

for ventilating, heating, and air-conditioning ducting

Ventiduct flexible coupling is a stainless-steel unit designed for making strong, vibration-resistant joints in ventilating, heating and air-conditioning systems, and other commercial ducting. It is nonmagnetic and noncorrosive in moist atmospheres. Only one nut and bolt are required to close coupling, enabling simple, rapid installation in partitions or in close clearance work. Segmented coupling strip is supplied in 3-ft lengths for sizes from 3 to 12 in.; clips are furnished

Stearns Tech-notes on electro-magnetic BRAKES CLUTCHES

(choice of the leading motor manufacturers)

(Second of a Series)

DETERMINATION OF THERMAL EQUIPMENTS FOR *Matched-to-the-Machine* PERFORMANCE

Thermal capacity . . . the measure of a unit's ability to dissipate heat . . . can be just as important as torque requirements when choosing clutches or brakes that will deliver top performance. Stearns engineers, with knowledge gained from forty years' experience in the field of applied magnetics, plus roughly half a million successful brake and clutch installations, are experts in *Matched-to-the-Machine* applications.

HEAT DISSIPATION — Thermal capacity . . . rate of heat dissipation is critically important when brake or clutch must rapidly and frequently start or stop high-inertia loads operating at high speeds. Requirements can be determined from the following equation:

$$\text{HP sec./Minute} = \frac{WK^2 \times RPM^2 \times N}{3{,}220{,}000}$$

WK^2 = inertia of rotating load in lb ft^2.
N = starts or stops per minute.
RPM = revolutions/minute of rotating mass.

Note that rpm enters the equation as a squared function, indicating that thermal requirements are of particular significance at higher speeds.

EXAMPLE:

$WK^2 = 4$ ft lb^2
N = 5 stops/minute
RPM = 1800

$$\text{HP sec./Minute} = \frac{4 \times (1800)^2 \times 5}{3{,}220{,}000}$$

HP sec./Minute = 20

Stearns Brake #H-74 has a thermal rating equal to the above value, and would be adequate for this application.

When linear motion is also present, its kinetic energy must be accounted for by means of the following equation:

$$\text{HP sec./Minute} = 2.8 \times 10^{-5} WV^2N$$

W = Weight (lb) of the moving load
V = velocity in ft/sec.
N = stops/minute

EXAMPLE:

W = 500 lb
V = 3 ft/sec.
N = 5 stops/minute
HP sec./Minute = (2.8×10^{-5}) (500) $(3)^2(5)$
HP sec./Minute = .623

HEAT ABSORPTION — This factor is important when starting or stopping extremely high-inertia loads at relatively infrequent intervals. For these applications, total kinetic energy (K.E.) of the system can be determined from this equation:

$$\text{K.E.} = \frac{WK^2 \times RPM^2}{5875}$$

K.E. = Kinetic Energy in ft lb
RPM = Speed of rotating member
WK^2 = moment of inertia of rotating mass

EXAMPLE:

$WK^2 = 30$
RPM = 1800

$$\text{K.E.} = \frac{30 \times 1800^2}{5875}$$

K.E. = 16,500 ft lb

In the example above, the value falls within the rating of an H-74 Stearns Brake, but sufficient time must be allowed between stops to prevent abnormal temperature rise. Again, if linear motion is present, its kinetic energy must also be considered.

Suitable corrections must be made if speed conversion devices are used between clutches, brakes, and the moving mass. For optimum performance such factors as ambient temperature, type of load, and altitude should also be taken into account.

For practical solutions to your starting-stopping problems . . . for *Matched-to-the-Machine* performance . . . call on Stearns with confidence. For clutches and brakes . . . whatever your torque requirements — thermal considerations — design limitations — or size for your application . . . Stearns has a standard unit, or will design and build units specifically for your requirement. Stearns brakes and clutches offer precise control . . . smooth starts and stops . . . visual indication of need for adjustment . . . fast maintenance . . . plus important cost savings in installation and operation unobtainable elsewhere.

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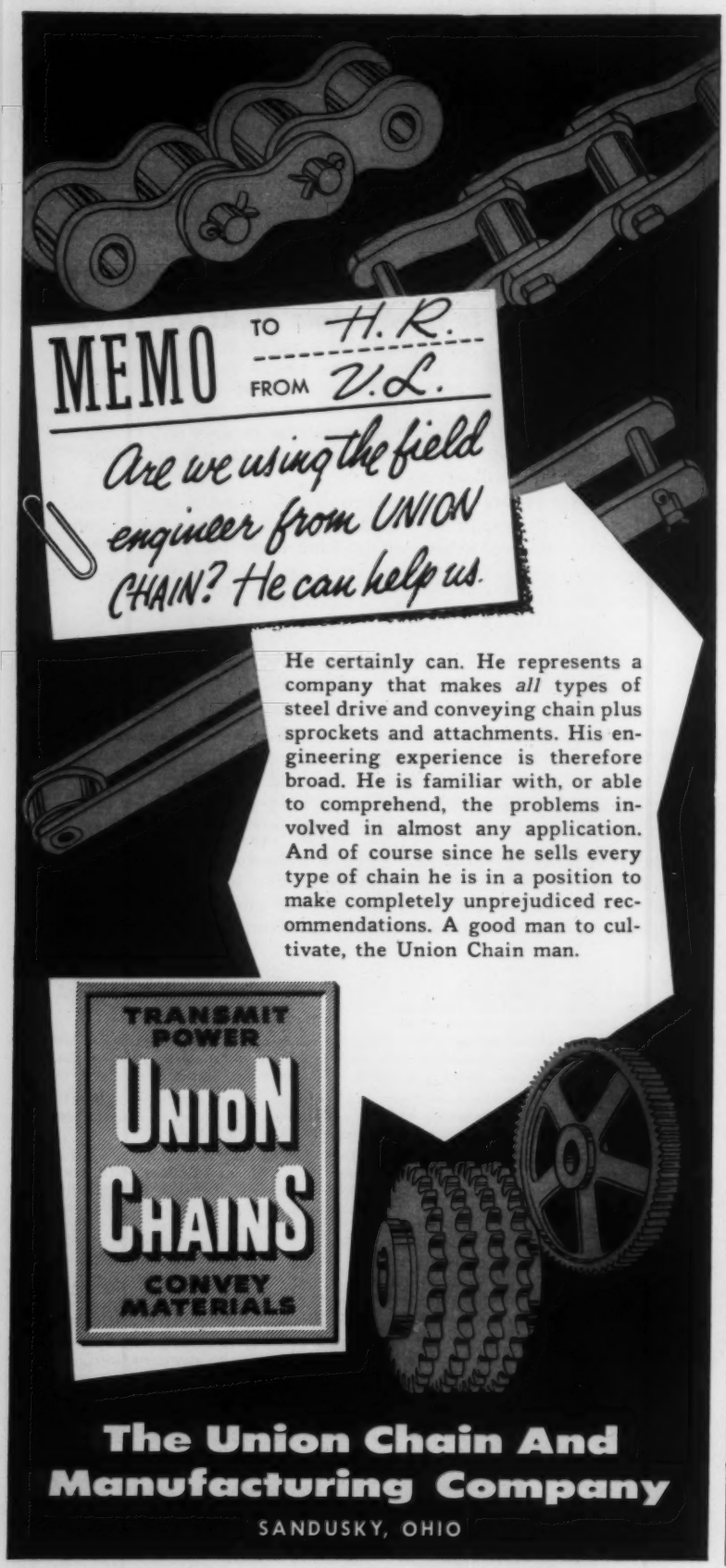
Call the Stearns representative in your vicinity for complete data on electro-magnetic clutches, brakes, and clutch-brake combinations. Or write, outlining your specific requirements directly to . . .

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

Circle 530 on Page 19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in pairs. Duct diameters over 12 in. can be accommodated by using two or more complete coupling strips and two or more pairs of clips. **Marman Div., Aeroquip Corp.**, 11214 Exposition Blvd., Los Angeles 64, Calif. L

Circle 703 on Page 19

Butyl Compound

has low compression set

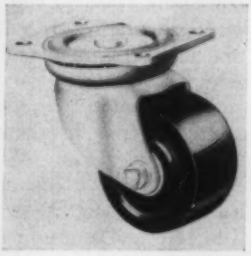
Compound 9257 is a low-compression-set butyl which shows excellent resistance to deterioration by air at 250 F. Material has set of only 44 per cent after 70 hr at 212 F and 56 per cent at 250 F. Compound shows good resistance to synthetic hydraulic fluids such as Skydrol, Skydrol 500, and Skydrol 7000, and also to trinormal butyl phosphate and cellulubes. It has excellent resistance to acid concentrations up to 50 per cent at ambient temperatures, and to gas permeation. **Precision Rubber Products Corp.**, 3110 Oakridge Drive, Dayton 7, Ohio. G

Circle 704 on Page 19

Heavy-Duty Caster

has 3-in. diam wheel with 500-lb load capacity

New S-99 caster with wide Canaphin phenolic-canvas molded-composition wheel is useful where low overall height is important. Caster raises load only 4 5/16 in. above floor and maintains low center of gravity with easy swiveling action. Unit has 3-in. diam wheel which carries



Circle 531 on Page 19

500-lb load, or 2000 lb per set of four. Caster was designed especially for heavy electronic business machines, and is recommended for use where heavy equipment must be made portable but is moved only occasionally. **Bassick Co.**, 3045 Fairfield Ave., Bridgeport 5, Conn. B

Circle 705 on Page 19

Sealing Tape

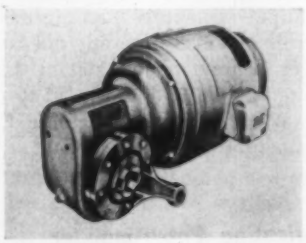
for glass and metal seals

No. 1072 butene sealing tape is a black, rubbery material for glass-to-metal, glass-to-glass, and metal-to-metal bonds. The tight-sticking material maintains elastic and resilient qualities while providing weathertight, durable seals. It resists temperatures from −45 to 250 F and ultraviolet exposures. Applications include use in the building, aircraft, appliance, automotive, and marine industries. Tape is available in roll form with release-free liner paper. **Suydam Div., Pittsburgh Plate Glass Co.**, Island & Preble Avenues, Pittsburgh 33, Pa. F

Circle 706 on Page 19

Motor Reducer

has hollow shaft to permit direct coupling to equipment



New right-angle Motoreducer unit is available with standard single-speed motor, or in power packages incorporating magnetic brakes, slip rings, two-speed and fluid-shaft drive motors. Unit incorporates a hollow shaft that permits direct coupling to equipment by inserting drive shaft of a machine. Reducer can be mounted in limited spaces, and in almost any position. Power range is from ½ to 2 hp, with 13 gear-reduction ratios and speeds from 18 to 250 rpm. **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif. L

Circle 707 on Page 19

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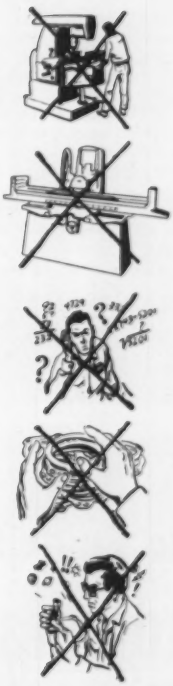

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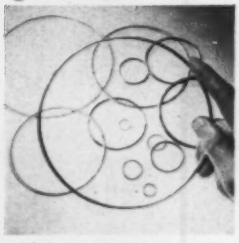
Circle 532 on Page 19

Too many shrimp cocktails for this fella, but the circus will have him sober and back on the ball tomorrow. Here's a clear-headed suggestion, too, for tight seal problems involving metal-to-metal applications: buy United's Metallic O-Rings.

They fit any application calling for a positive, permanent seal against internal or vacuum pressures up to 10,000 p.s.i., in a temperature range from 70 to 1800°F. They are especially adaptable for sealing cylinder heads, air and hydraulic pressures, high octane fuels, vapors, gases, oils, solvents, chemicals, acids, vacuum and steam connections. Available in various metals and plating finishes, from 3/8" dia. to any size or configuration.



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Circle 533 on Page 19

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EQUIPMENT

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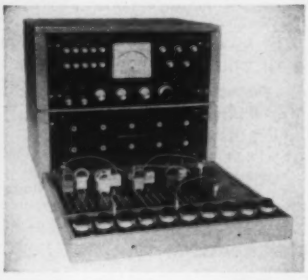
Desktop analog computer, designated Model 3400, has ten chopper-stabilized amplifiers, built-in null voltmeter, cyclic reset generator, all power supplies, and problem board. Designed for engineering analysis and research, unit offers 0.1 per cent performance with chopper-stabilized, printed-circuit amplifiers. Positive and negative reference voltage is available at removable problem board. Simultaneous control of multiple computer arrangements can be obtained from any one computer or from remote station. Unit operates from 115/230-v, 50 to 60-cps power. Donner Scientific Co., Galindo Street, Concord, Calif. M



Circle 708 on Page 19

Indicating Potentiometer

measures variable such as speed, pressure, temperature

New indicating model of Dynamaster self-balancing electronic potentiometer is designed for use when legibility of indicating scale from greater distances is important. Unit has 32-in. scale and same pointer as standard recording unit, but is equipped for indicating only. Instrument is also available in electric-control models, in on-off, two-position, three-position, floating, proportional, and current-input types of control. It measures such variables as temperature, speed,

(Advertisement)

Design Analysis On Fasteners and Small Parts

Shows Cold Heading Usually Cuts Costs

This may very well be the age of "Design Analysis". And, one of the most promising fields for such a cost saving study is fasteners and small parts. Actually one of the most important cost cutting developments in recent years is the increasing use of cold headed parts and fasteners in place of more expensive and structurally weaker screw machine products.

The more expensive bar stock used in the screw machine method results in considerable waste, whereas the waste is almost negligible in cold heading.

Another important consideration is the greater strength structure of parts made by the cold heading method. The blow of the heading tool causes the grain structure of the metal to flow in lines of greater strength.

The possibilities of cold heading are almost unlimited when used in conjunction with secondary operations. The tremendous savings in operation and material costs make it a must consideration when designing small parts either as fasteners or as integral units for manufactured parts. It has been a long time policy of John Hassall, Inc. to support their cold heading equipment with the latest methods of secondary manufacture. Machines for roll threading, slotting, drilling, tapping and many other operations are available for your profit.

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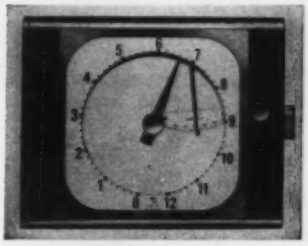


pressure, smoke density, pH, and electrical values. **Bristol Co.**, Waterbury 20, Conn. B

Circle 709 on Page 19

Tracing Film

accepts up to 6H pencil

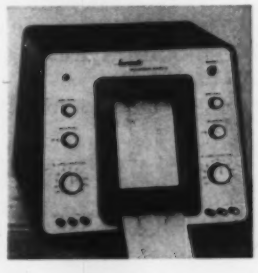
New, durable tracing film for engineering tracings, architectural drawings, and type-on masters, known as Duratrace, has an excellent surface for pencils to 6H. Material can be used to combine Polaroid transparencies with typed material for uses such as illustrating specification sheets. Duratrace has a newly developed surface on 0.002-in. Mylar base. Material is nonyellowing and waterproof, has excellent dimensional stability, high degree of transparency, and higher strength than tracing cloth or paper. It is available in 20 yd x 36-in. rolls and also in standard cut-sheet sizes. **Ozalid Div., General Aniline & Film Corp.**, 15 Corliss Lane, Johnson City, N. Y. D

Circle 710 on Page 19

Dual-Channel Recorder

has pushbutton control of four chart speeds

Mark II dual-channel recorder provides visible, permanent chart recordings on two channels over a wide amplitude range. Frequency range is dc to 100 cps, with sensitivity of 10 mv per chart line. Four chart speeds of 1, 5, 25, and



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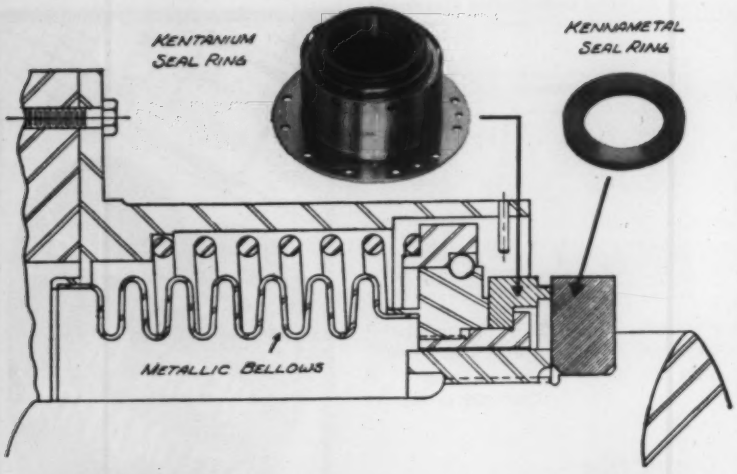

KENNAMETAL* Rotary Seal Rings provide substantially zero leakage at mile-a-minute rubbing speeds

At rubbing speeds of 4200 to 5400 ft./min., the hydraulically balanced seal shown above achieves substantially zero gas leakage. Excellent wear characteristics of the Kennametal and Kentanium* Seal Rings featured in this design make possible unlubricated dry rubbing at peak speeds.

Stein Seal Company, Philadelphia, Pa., solved major sealing problems on many applications by using Kennametal and Kentanium parts in their hydraulic balanced seal design such as illustrated above. By using rings made of these hard carbide, wear-resistant compositions, it is possible to operate with higher spring forces and in much higher temperatures than when rings of conventional sealing materials are used.

The outstanding physical properties of Kennametal compositions have provided many more answers to rotary seal ring problems in the fields of petroleum refining and transportation, high-pressure high-temperature chemical production and nuclear power. For example, K501, a platinum-bonded carbide, is being used to confine liquid oxygen and red fuming nitric acid. Results are reported by the customer to be "far superior to any previously-used materials, with no indication of face wear."

Various grades of Kennametal compositions hold economical answers to *your* need for high YME, low thermal expansion, high resistance to abrasion, erosion, corrosion, impact and pressures. For positive sealing, with little or no maintenance, mating surfaces of Kennametal Seal Rings can be lapped to a flatness less than two light bands, with a surface finish better than two microinch.

For more information, send for Booklet B-111A, "Characteristics of Kennametal." Write to Dept. MD KENNAMETAL INC., Latrobe, Pennsylvania.

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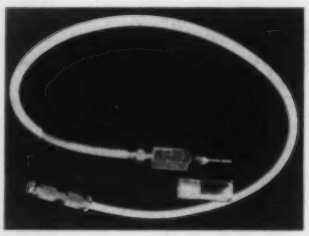
125 mm per sec are selected by pushbutton control. Pull-out writing table provides fast paper loading without threading. Recorder weighs 32 lb. Writing system features self-cleaning, self-priming pens and large ink reservoir. **Brush Instruments, Div., Clevite Corp.,** 3405 Perkins Ave., Cleveland 14, Ohio. G

Circle 711 on Page 19

Temperature Transducer

has response as fast as 10 millisec



Probe-type temperature transducer measures static and flow temperatures of liquid gases used in rocket motors, tank storage, and process control. It measures temperatures of air, water, ethyl alcohol, liquid nitrogen, liquid oxygen, gaseous nitrogen, lubricating and hydraulic oil, and other fluids. Unit withstands acceleration to ±25 g at 0 to 200 cps. Exposed element in unit provides response as fast as 10 millisec. Accuracy is better than 0.1 F, and resolution of 0.1 F is obtainable. Maximum operating current is 5 ma. Operating range is −450 to 2000 F in eight increments. **Astra Technical Instrument Corp.,** 1132 Mission St., South Pasadena, Calif. L

Circle 712 on Page 19

Reproducible Data Sheet

for test data and plots of performance results

A single sheet of Easyplot M1001 reproducible data sheet comprises cross-section sketch area, columns to record ordinate and abscissa history, and sections for plots of results. Paper is particularly useful for presenting development, [illegible]ation, or statistical information [illegible] available in 50-sheet pads of rag vellum. **Spectrum Design Associates,** 1185 State St., Bridgeport, Conn. B

Circle 713 on Page 19

THE ENGINEER'S

Library

Recent Books

Handbook of Noise Control. *Edited by Cyril M. Harris, Associate Professor of Electrical Engineering, Columbia University; 1011 pages, 6 by 9 in., clothbound; published by McGraw-Hill Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$16.50 per copy postpaid.*

Various aspects of "unwanted sound" and its control are treated in this handbook through discussion on the nature of noise, its measurement, and techniques of its control.

Such general subjects as vibration control, sources of noise, and noise control of machinery, electrical, automotive and aircraft equipment are covered. With existing installations serving as examples, emphasis is placed upon actual solutions to noise problems.

Control Engineers' Handbook. *Edited by John G. Truxal, Head of the Electrical Engineering Department of the Polytechnic Institute of Brooklyn; 1048 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Company Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$18.50 per copy postpaid.*

This handbook provides a basic source of information on components and techniques for use in the design of feedback control systems. Emphasis is placed largely on components including electromechanical, mechanical, hydraulic, and pneumatic as well as electronic and magnetic.

Information on how components are assembled in the design of feedback control systems and specific discussions on regulators, and process control systems are also presented.

Engineering Materials Handbook. *Edited by Charles L. Mantell, Chairman of the Department of Chemical Engineering, Newark College of Engineering; 1952 pages, 6 by 9 in., clothbound; published by McGraw-Hill Co. Inc., 330 West 42nd St.,*

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ASTM Standards on Glass and Glass Products. 138 *pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $2.50 *per copy to nonmembers.*

Contained in these standards are specifications and methods of testing for glass, glass containers, insulators, and glass fabrics.

ASTM Standards on Adhesives. 244 *pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $3.50 *per copy to nonmembers.*

Specifications, physical tests, and definitions of adhesives are compiled in this book of standards.

Association Publications

Computer Applications. 126 *pages, 6 by 9 in., paperbound; published by and available from Armour Research Foundation of Illinois Institute of Technology,* 10 *West 35th St., Chicago* 16, *Ill.;* $3.00 *per copy.*

Various applications of computers in business, engineering, and research are presented in this group of 14 papers submitted at the Fourth Annual Computer Application Symposium.

Material for Instruments in Radiation Service. 12 *pages,* 8½ *by* 11 *in., paperbound; published by and available from Instrument Society of America,* 313 *Sixth*

Ave., Pittsburgh 22, Pa.; $.50 per copy to members, $.75 non-members.

This tentative recommended practice report is intended to serve as a guide to the selection of materials for use in motor, control, and instrumentation components exposed to intense radiation fields.

Government Publications

The Properties of Titanium Alloys at Elevated Temperatures. PB-121634. *By F. R. Schwartzberg, F. C. Holden, H. R. Ogden, and R. I. Jaffee; 213 pages, 8½ by 11 in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $6.00 per copy.*

Available data on the mechanical properties of titanium alloys at elevated temperatures have been collected and compiled in this report. Properties presented include short-time strengths and creep, rupture, bearing, shear, and notch strengths. Also included is a discussion on the thermal stability of titanium alloys.

Principles and Application of Heat Treatment for Titanium Alloys, PB 121636. *By A. J. Greist and P. D. Frost; 132 pages, 8½ by 11 in., paperbound; published by and available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $3.50 per copy.*

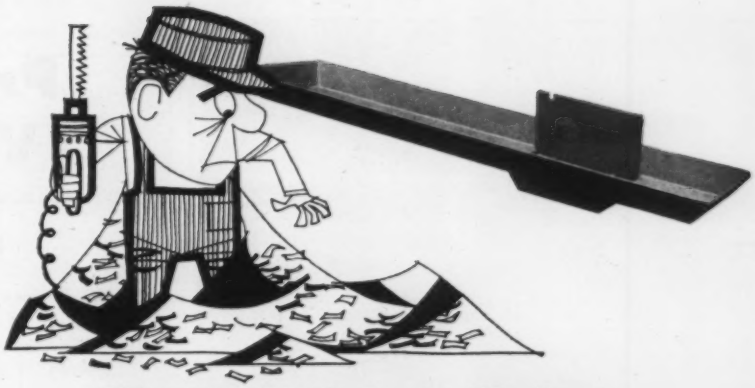
This report contains information on the background for the heat treatment of titanium alloys, properties of selected commercial titanium alloys in the heat-treated condition, and practices in heat treating titanium alloys.

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1512 H St. N. W., Washington 25, D. C.*

The following publications are available:

TN 4218. Analysis of Stresses and Deflections in a Disk Subjected to Gyroscopic Forces. *By M. H. Hirschberg and M. A. Mendelson; 37 pages.*

TN 4206. Measurements of Total Hemispherical Emissivity of Various Oxidized Metals at High Temperature. *By William R. Wade; 43 pages.*



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Professional Viewpoints

. . . professionals or workers . . .

To the Editor:

I would like to comment on one aspect of the article "Professionals or Workers?" by Edwin C. Nevis (MACHINE DESIGN, March 6, 1958). It is his concept that overtime pay for engineers is unprofessional.

As stated in the article, I would much prefer to see each engineer assigned a job and then leave the hours of work to him. However, there is nothing at all to keep an employer from assigning each engineer a job, with its associated deadline, which would normally require 60 or 80 hours of work per week.

It is the rule rather than the exception that engineers are required ordinarily to be present at their work location during certain stipulated hours. Further, it is not uncommon for an employer to require an engineer's presence on evenings, Saturdays, or Sundays. Sometimes his presence is required simply because the rest of the group is working even though his personal assignment might not require his presence; I call this "sympathetic" overtime.

So long as an employer is free to stipulate an engineer's hours of work, or to impose work assignments on him which in turn require certain hours of work, the engineer is working on an hourly rate whether anyone explicitly recognizes this fact or not. In order to discourage an excessive imposition upon the engineer's free time, or to partially compensate for it where such imposition is required, I am convinced that a premium rate is warranted and appropriate.

Mr. Nevis, in his article, in effect, recognizes this. He says, "An increased basic salary or bonus arrangement, rather than hourly overtime, is the more professional arrangement." Presumably, when an engineer is working normal hours next vear, he would propose a decreased basic salary or bonus. This is clearly compensation for overtime although perhaps using a different formula. Thus, Mr. Nevis and I are not differing in principle but only in method.

The attitudes which he expresses are not uncommon. In fact, I believe considerable confusion exists in many people's minds as to why premium compensation *is* appropriate. I suggest that the reason for the confusion is the implied premise that any working condition which is accorded to nonprofessional workers must be, per se, nonprofessional. The article refers to this when the author says, ". . . a professional person is injured when he adopts practices which are common among groups of lesser status . . ." I believe that this idea is demonstrably false. For example, would Mr. Nevis propose no sick leave, holidays, retirement plan, etc., simply because the factory workers enjoy them?

I agree that professional engineers need to give very careful attention to their professional status and to differentiate themselves from the hourly workers wherever

this will enhance their professional status. However, a case for the idea that premium compensation for overtime is unprofessional has not been made.

—JOSEPH AMANN
Engineers and Scientists of America

To the Editor:

I believe that Mr. Amann misses the main point of my article; perhaps I have not been clear enough in bringing it out. This point is essentially that engineers, in seeking fair treatment from management groups, often tend to express their grievances and to seek rewards in ways which are more typically used by groups of lesser status in industry. Mr. Amann raises a straw man in taking me to task on this issue. He makes the point that, were there no provisions for overtime pay, employers would have engineers doing "60 or 80 hours of work per week." While I am well aware of the advantage which is sometimes taken of engineers, under current philosophy of management and economic conditions, no employer is likely to go very far in this respect and retain the services of employees who are so maltreated for very long.

Mr. Amann's point about fringe benefits is well taken, and I certainly would not suggest that engineers give these up. But I do suggest that when management people—those who have higher status in industry—bargain about jobs and think of what it is that provides the real challenge and incentive in their work, such things as fringe benefits generally rate quite low. While such things may undoubtedly be important aspects of the job, the factors which give such positions status are more likely to be salary level and the level of responsibility.

In brief, I would like to repeat the point that I tried to make: If engineers feel that they are being asked to work long hours, they have every right to demand more money, but they should be given proper compensation in their base pay arrangements. If engineers wish to be seen as members of management, i.e., as professionals, they cannot have their cake and eat it too, by assuming certain prerogatives of workers when this suits their purposes and others of management when the latter meet their needs. It is a fundamental point in the psychology of social roles that we tend to be seen by others as we see ourselves.

Overtime pay is not a reward for exemplary service or recognition of an individual's merit. It is only a reward for putting in extra time, and in no way enhances the professional prestige or status of the engineering people who are willing to accept it.

If I wanted to convince my superiors of my value and increase my status, I would fight as hard as I could to act and think as they do in regard to their job attitudes. I would fight for more money (or fewer hours) if this seemed important, but I would use levers to impress my superiors as well as to "budge" them. Demands for overtime pay programs do not impress executives, at least not in my experience. Demands for higher annual salaries and correspondingly increased responsibilities do.

—EDWIN C. NEVIS
Personnel Research and Development Corp.

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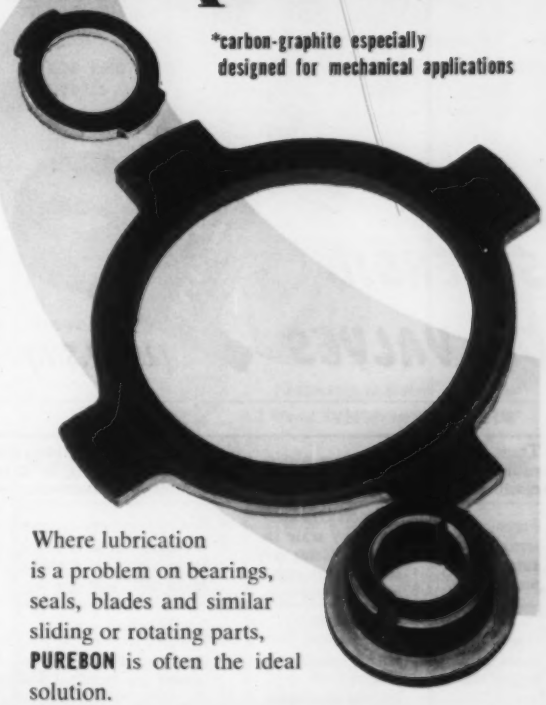

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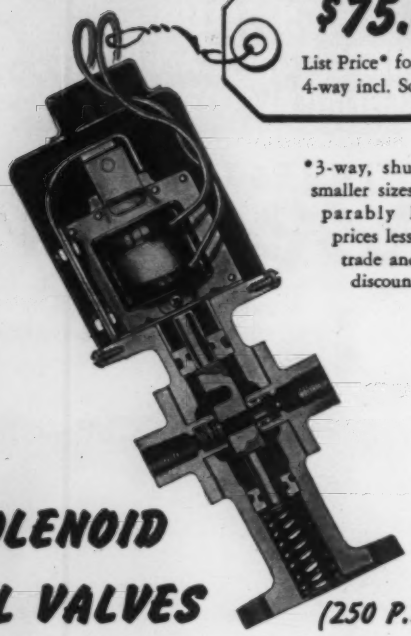

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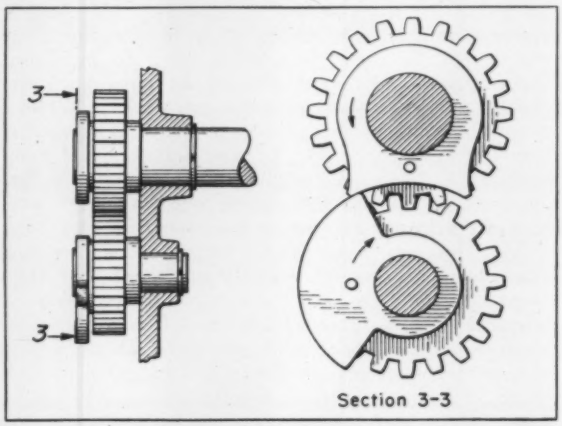
NOTEWORTHY

Patents

Gear Limit-Stop Mechanism

Interference of convex and concave cams in a hunting-tooth limit-stop mechanism blocks rotation of a shaft after a predetermined number of turns. Sketch shows



mechanism blocked after counterclockwise rotation of the upper drive gear. Because the driven gear (bottom) has one less tooth than the drive gear, the drive gear in the configuration shown here can rotate freely through ten clockwise turns before cam interference again blocks movement. Number of turns permitted between stop engagements is varied by changing the width of the driven-gear cam. *Patent* 2,823,561 *assigned to Librascope Inc., Glendale, Calif., by Willard J. Opocensky.*

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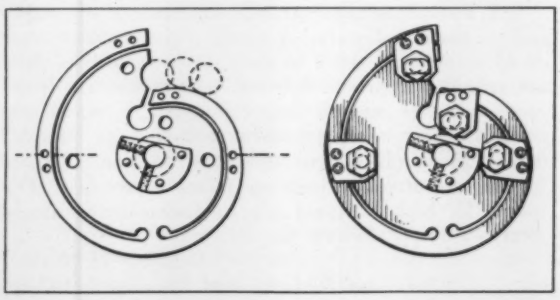
Contour of an adjustable-cam design can be quickly modified to compensate for variable factors in the system under control. Adjustment feature is provided by a slot separating the cam profile from the cam body. Spaced tabs and eccentric screws allow precise adjustment of the contour. Typical use is in compensating



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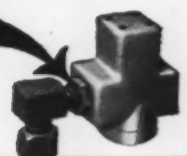

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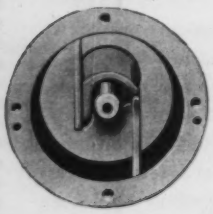

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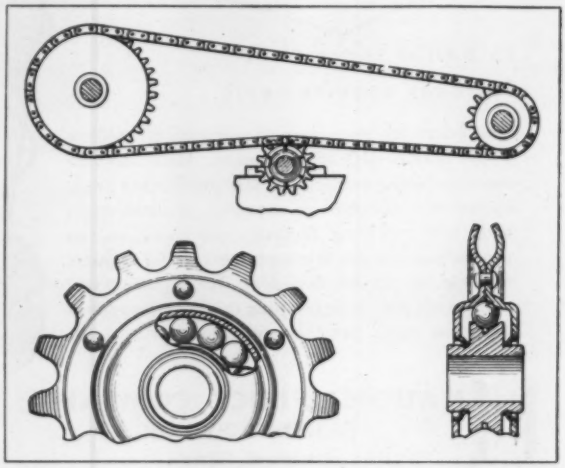

systems. Sealed lubricant reservoir in sprocket hub insures long operating life without necessity for frequent relubrication. Integral bearing simplifies installation by allowing idler to be bolted to any convenient bracket or frame member. *Patent 2,823,553 assigned to Parkersburg-Aetna Corp., Chicago, Ill., by Richard F. Harrington.*

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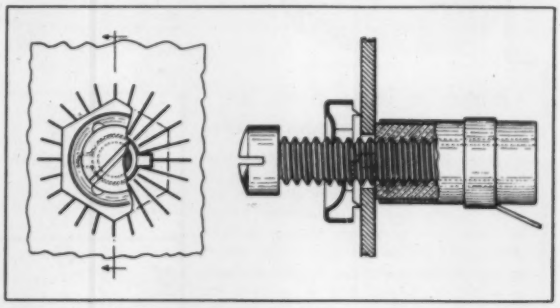

holds the adjusting-screw secure against vibration. During assembly, nut and screw are run in together until the nut bottoms against the chassis plate; the nut is then turned on the screw to firmly clamp the component against the chassis plate. Teeth on the bottom of the nut dig into the chassis, preventing further rotation when the adjusting screw is turned in either direction. *Patent 2,824,480 assigned to Palnut Co., Irvington, N. J., by James R. Hotchkin.*

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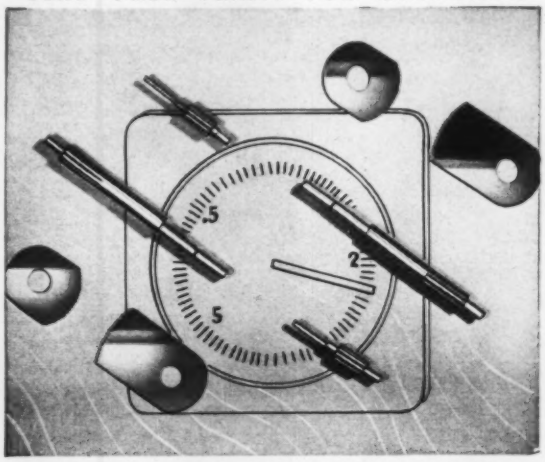

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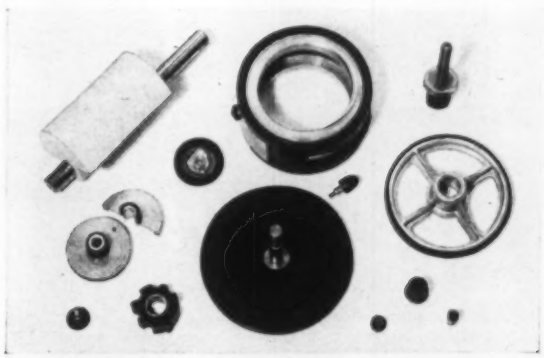

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Let us know of your bonding problems and kindred requirements. Our engineers will be pleased to work with you and make recommendations.

Send for
New WILBOW Catalog
It will become your handbook of rubber goods

wilbow

The WILLIAMS-BOWMAN RUBBER Co.

1951 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

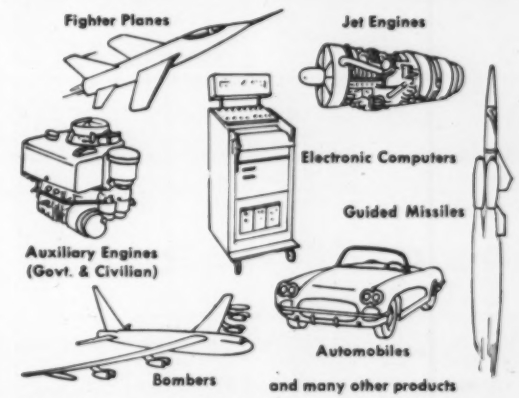
Circle 556 on Page 19

TAP-LOK®

the best, simplest, lowest-cost threaded fastener insert

— bar none!

TAP-LOK Quality is Proven by Current Use in



Tap-Lok Inserts provide heavy-duty steel threads for threaded fasteners in light metals, plastics and many other materials. They excel in saving time and cost in assembly, among all types of bushings designed for this purpose.

Tap-Lok Inserts are **SELF-TAPPING** and friction-locking in a single step. They increase thread strength 50% or more. They require no separate tapping operation, special hole preparation or secondary staking.

Tap-Lok Inserts are made in two types—the Regular Series, with a 2B internal thread for general applications in aluminum, magnesium and zinc die castings and sand castings; and the "H" Series, with 2B or 3B internal thread for use in wrought and high strength aluminum and magnesium castings, as in aircraft applications.

In accordance with MS 35914.

SEND FOR FURTHER INFORMATION.

GROOV-PIN CORPORATION

1130 Hendricks Causeway, Ridgefield, New Jersey
TWX: Cliffside 26
IN CANADA: Metal and Wood Fastening Devices Co., Valois, Montreal
Also manufacturers of Groov-Pins for positive locking press fit.

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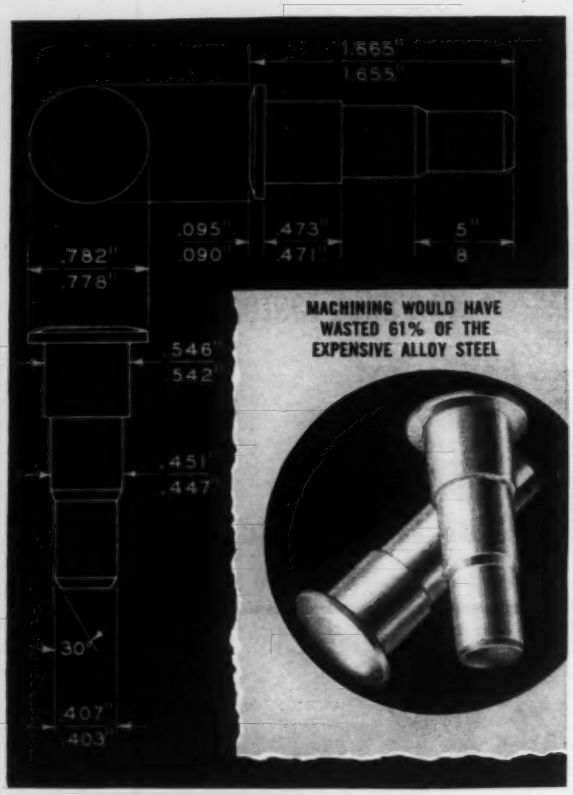


hard steel stud saved

by cold heading

The tough alloy-steel (4615 or 8615) used for this stud created a production problem. Machining would waste a lot of metal. Even cold heading seemed wrong, because of the hardness and poor flow characteristics of the metal.

But Progressive did it. We cold headed it—and produced naturally stronger studs. We used bar stock of nearly half the diameter needed to machine it, and got over 2½ times as many studs from the same amount of metal.

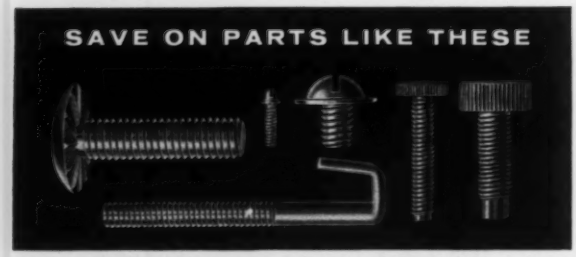
You can make similar savings. Write for more case histories in our *"Bank Book of Savings in Cold Heading."*

MACHINE SCREWS AND NUTS, SEMS FASTENERS, SLOTTED TAPPING SCREWS AND PHILLIPS HEAD SCREWS

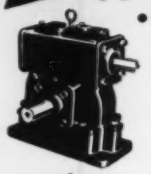
THE PROGRESSIVE MFG. CO.

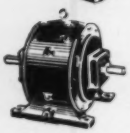
Division of The Torrington Company

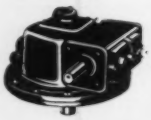
52 Norwood St., Torrington, Connecticut



AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.







Horizontal or vertical drives; inputs from either side; right, left, top or bottom outputs. A size and type for every application. Ratings from 1/20 to 400 h.p. Ratios up to 10,000 to 1.

Compact precision-built Abart Speed Reducers make the most of your power. Simplified trouble-free design and construction assure lower operating and maintenance costs.

Write today for Abart's fact-packed pocket size speed reducer catalog. See the results of 30 years of careful specialized study on thousands of speed reduction problems.

ABART GEAR and MACHINE CO.

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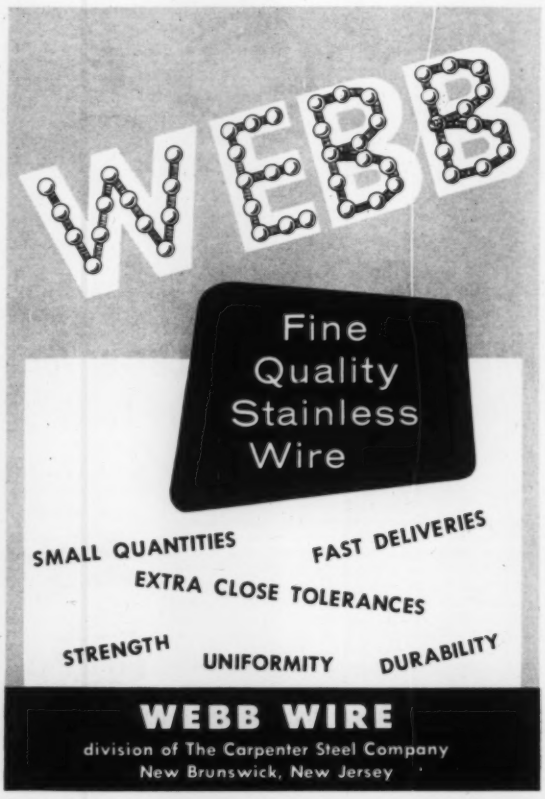

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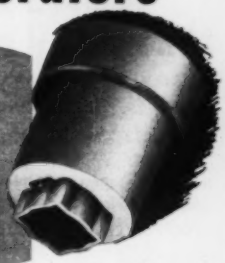
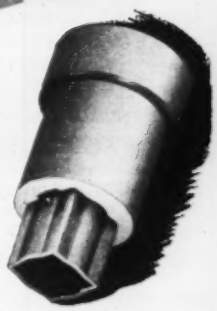
High-Impact-Strength High Temperature

BRUSH HOLDERS





New PHOENIX "Pemester"

High performance Phoenix "Pemester" Brush Holders and Caps are for motors that get the really rugged duty... new "Pemester" material gives high-impact-strength, dimensional stability up to 400°F. and molds to close tolerances in any quantity . . . Available *only* from Phoenix in the complete "Customized-Standard" line of sizes and types—or to your specifications.

Write for full information contained in big, new, easy-to-use Phoenix Catalog 57-L. Your copy free on request.

PHOENIX ELECTRIC MANUFACTURING CO.

4211 West Lake Street · Chicago 24, Illinois

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Here's the Answer to Accurate Timing of Electrically Operated Equipment

ZENITH INTERVAL TIMER

Especially recommended for operation of blowers, pumps, agitators, mixers, conveyors and other machinery . . . widely used for plastic moulding, rubber curing, heat treating, enamel baking, light exposure and similar operations.

Fully enclosed. Double-throw, single-pole switch. Self-starting slow speed industrial type synchronous motor. Time range: 60 seconds to 72 hours.

Send for full information, including bulletin on Zenith's complete line of automatic control equipment.

ZENITH ELECTRIC CO.

149 WEST WALTON STREET · CHICAGO 10, ILLINOIS

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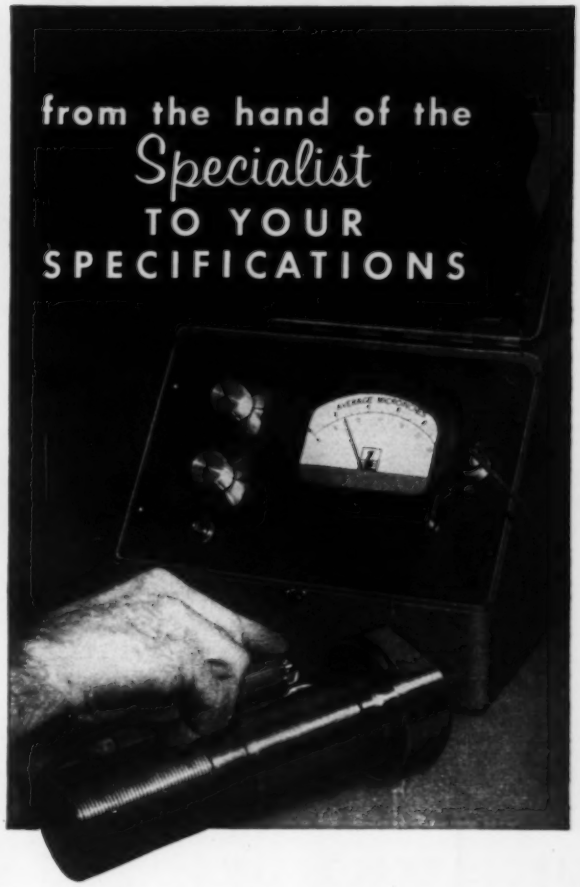

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In Alloys · Stainless · Carbon · Bronze

The reading on this Surfindicator measures more than just the fine finish on this special bolt. It measures the result of the precision craftsmanship your own specifications receive at Erie Bolt & Nut Company. Producing a wide variety of special fasteners to resist corrosion, extremes in temperature and tensile stresses as specified is our exclusive job . . . has been for almost half a century.
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Erie, Pennsylvania

Representatives in Principal Cities

Circle 563 on Page 19

this lens magnifies sales

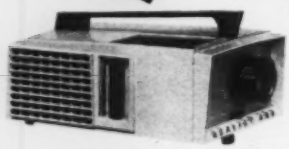
There's a mass-market price tag on this new Realist 620 color slide projector. Easy to see why. Realist used a low-cost aspheric lens by Lancaster—for a brighter sales picture.

Want lower unit costs for your product? Let Lancaster design the glass and plastic components.

design flexibility in glass

Lancaster glass and plastics

...to brighten your product's future



LANCASTER GLASS CORPORATION • Lancaster 2, Ohio

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NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝" . . . width—1 13/16" . . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A30-528.

AGA ELASTIC STOP NUT CORPORATION OF AMERICA

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

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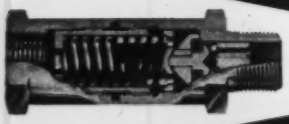
CIRCLE SEAL VALVES

provide proven 100% reliability...

Check Valves

Inline Relief Valves



Popoff Relief Valves

Shutoff Valves

These and other standard and special valves are available for virtually all of your exacting service requirements.

CIRCLE SEAL

Complete engineering data available. Write today!

CIRCLE SEAL PRODUCTS COMPANY, INC.
2181 East Foothill Boulevard
Pasadena, California

See Our Catalog in Sweet's Product Design File

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For HIGHEST ELECTRICAL & MECHANICAL *Efficiency!*

New

JONES 2400 SERIES PLUGS & SOCKETS

Improved Socket Contacts. Four individual flexing surfaces. Positive contact over practically their entire length.

Both Plug and Socket Contacts mounted in recessed pockets greatly increasing leakage distance, INCREASING VOLTAGE RATING.

Plug and Socket Contacts cadmium plated. Add to appearance of your equipment.

Interchangeable with Jones 400 Series.

Ask for Catalog 21. Complete line Jones Plugs, Sockets, Terminal Strips.

P-2406-CCT
Plug—with cable clamp in top.

S-2406-SB
Socket with shallow bracket for flush mounting.

Jones

HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24 ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

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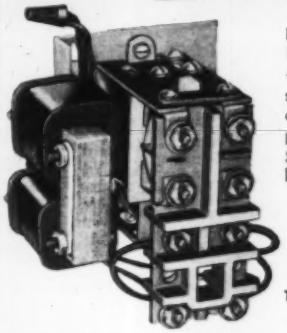
WARRICK Floatless Electrode Type LIQUID LEVEL CONTROLS . . .

give you all these advantages!



No moving parts in the liquid • Easy to install • No adjustments necessary • Unaffected by acids or caustics • Unaffected by pressure or temperature • Standard 2&3 pole units listed by U/L

Write for 32-page Catalog which gives complete specifications

Two pole control shown at left

YOU CAN USE OUR CONTROLS FOR:

- Single & multiple pumps
- Motor & solenoid valves
- High & low cutoffs & alarms
- Sewage & waterworks
- Chemical Industries
- Food & Dairy Industries
- OEM applications

Special controls to custom requirements

CHARLES F. WARRICK CO.

1964 W. Eleven Mile Road, Berkley, Michigan
Dep't 7 Telephone JOrdan 4-6667

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EASTMAN FLUID POWER LINES

Designed and Developed by **ENGINEERS** *for* **ENGINEERS**

Only Eastman can give you the above Split Flange with the advantages of Eastman's exclusive "Inter-Lock" Clamp:

1 **"Inter-Lock" Clamp for Best Hose Connection** — Accurate machining assures alternate positioning of ribs of clamp and barbs of insert—**avoids pinching and weakening of hose**—creating exclusive Eastman Inter-Lock grip.

2 **Split Flange for Tighter Seal at High Pressures**—Cuts production and replacement costs with a No-Thread, No-Leak "O" Ring Connection which eliminates threads, sealing compounds, spiral leaks and housing distortion.

Permanently Attached Flanged Head Couplings: ¼" thru 2" 375 to 5000 p.s.i.

Clamp Type Coupling with Split Flange Stems: ¼" thru 2" 375 to 5000 p.s.i.

Write for Eastman Inter-Lock Clamp Bulletin No. 40.

Rely on Eastman for quality—first to be specified by America's leading OEM's.

Eastman
MANUFACTURING COMPANY
Dept. MD-5A, Manitowoc, Wisconsin

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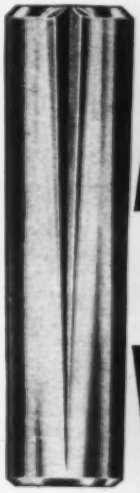
now-

SHEAR-PROOF ALLOY STEEL



DRIV-LOK PINS

for maximum resistance to

shear *shock* *fatigue*

- Drill a hole and drive them in . . . they're grooved and self-locking
- Provide the ultimate in physical properties at moderate cost
- Re-usable without loss of holding power

Now, you can get the efficiency, convenience and proven economy of DRIV-LOK Grooved Pins PLUS maximum resistance to shear, shock and fatigue, by specifying or installing *Shear-Proof* DRIV-LOK Pins. Made of alloy steel, heat treated to provide optimum physical properties and high shear values, Shear-Proof DRIV-LOK Pins are designed for critical applications where ultimate strength and reliability are mandatory. They are replacing alloy dowels, bolts, key and set screw assemblies, hollow pins (used singly, or one inside the other) in widely varied applications . . . thus saving time, labor and material. Write for special Shear-Proof DRIV-LOK Pin Catalog. Sample Type A Shear-Proof Pins furnished free on request.

type A standard

SPECIAL TYPES TO ORDER . . .

A3 B C D E U

COMPARE TYPICAL SHEAR VALUES (Minimum double shear strength in pounds)	Diameter	Slotted Spring Pins	Coiled Spring Pins HEAVY DUTY	SHEAR-PROOF DRIV-LOK PINS
	3/32	1000	1030	2040
	1/8	2100	1840	3690
	5/32	3000	2880	5720
	3/16	4400	4140	8240
	1/4	7700	7360	14720
	5/16	11500	11500	22960
	3/8	17600	16580	33160
	7/16	20000	22540	45000
	1/2	25800	29440	58900

DRIV-LOK SALES CORPORATION

715 PARK AVENUE • SYCAMORE, ILLINOIS

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molded
Black Nylon screws and nuts
Insulate and Fasten without bushings, washers, etc. In Stock 4-40, 6-32, 8-32, 10-32 and ¼-20.

Black Nylon "NyGrip" cable clips
Light-weight non-conducting support for wiring, tubing, etc. In Stock 1/16" to 1½" Dia.

Free samples • write **WECKESSER CO.**

5715 Northwest Hwy. • Chicago 30, Ill.

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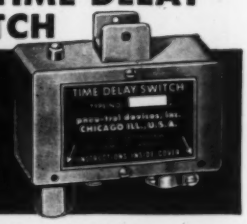
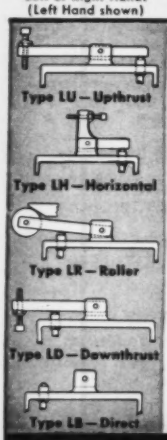
Pneu-Trol TIME DELAY CONTROL SWITCH

. . . Gives Cylinder Applications Greater Efficiency Accuracy . . . Wider Use!



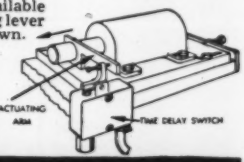
For any type actuation Left or Right Hand. (Left Hand shown)



- **Holds Cylinder dwell accurately to fraction of second.**
- **Automatically re-sets.**
- **Simple, Compact, Rugged.**

You can hold any motion or operation controlled or actuated by air or hydraulic cylinders at a positive stop on either end of the stroke for ¼ to 60 seconds in 20 to 1 ratios with Pneu-Trol Time Delay Control Switches. Simple in design with positive hydraulic timing action . . . compact and easily mounted on the machine or fixture, Pneu-Trol Switches are providing millions of trouble-free actuations in solenoid-operated cylinder applications of every type. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of the dwell. Available with 5 actuating lever linkages as shown.

Switch mounted to provide dwell at end of power stroke of single action, spring return cylinder.



Pneu-Trol DEVICES, INC.
1436 N. KEATING AVENUE • CHICAGO 51, ILL.

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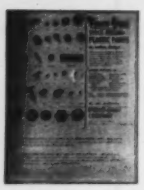
DIMCO-GRAY Stock plastic KNOBS...HANDLES



WRITE FOR THIS COMPLETE CATALOG

NO TOOL CHARGE!

Wide selection of stock knobs, handles and plastic parts available without tooling cost to you! Many minor changes (color, design, inserts, threads, special materials, etc.) can be made to meet your requirements.

DIMCO-GRAY COMPANY
204 EAST SIXTH STREET—DAYTON 2, OHIO

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ENGINEERS
AVAILABLE OR WANTED

AVAILABLE: Senior Mechanical Design Engineer for board work. High grade draftsmanship on assemblies. Superior ability on design of machinery, product, power press dies, production tools. Originality and ingenuity on new developments. Any location and length of engagement. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

Wanted: Mechanical Engineer. Opportunity available for mechanical engineer in central Ohio. Prefer 10 to 15 years experience in heavy structural and machinery design. Small company with annual sales in excess of $1,000,000. Expanding for the future. Address Box 929, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

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WARNER

electric motion control FACTS

Electric brakes synchronize automatic paper pasting!

Modern, high-speed news presses don't stop when they come to the end of a paper roll. The paster pilot, located beneath the press, automatically splices on the start of a new roll and cuts off the remnant of the old one while the press is operating at speeds up to 60,000 papers per hour.

Warner electric brakes prevent rocking, automatically release when splice is made

Electric brakes are mounted on each roll spindle (Fig. 1) and prevent the rolls from rocking motion sometimes caused by imperfect balance of the newsprint. With positive braking and automatic release, it is no longer necessary to manually brake the rolls or stop the press while a splice is being made.

When the new roll is indexed into pasting position, the brush and web-severing carriage is lowered, the pre-drive takes over, and the pasting is completed "on the fly." The paster pilot conserves newsprint by "sensing" press speed and automatically presetting the time for the pasting cycle, thereby producing uniform cores with 3/16 in. or less of paper.

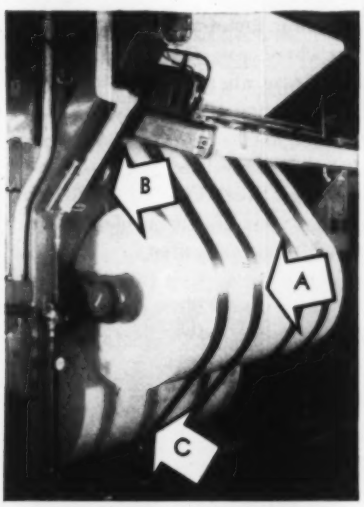


Fig. 1—Continuous printing is made possible by automatic paper splicing. Brush and web-severing carriage, directly above expiring roll (A), paste on the new roll (B), which then becomes the expiring roll. Loading roll (C) indexes into new roll position.

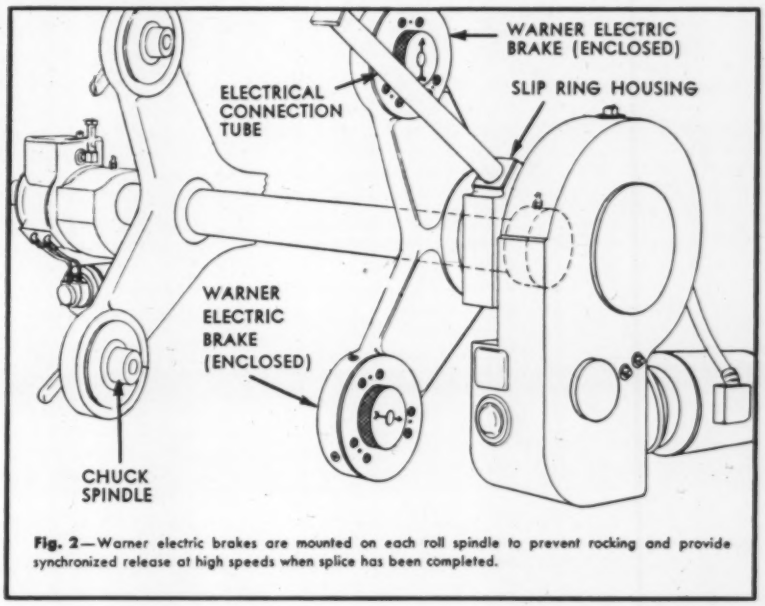
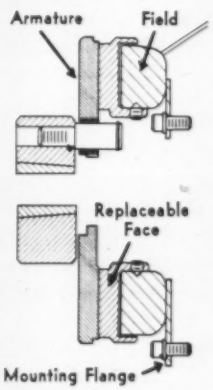


Fig. 2—Warner electric brakes are mounted on each roll spindle to prevent rocking and provide synchronized release at high speeds when splice has been completed.

Spacesaving design solves mounting problem



One of the design problems on this equipment was to fit the electric brakes into the compact, enclosed spindle indexing assemblies. Warner's compact armature-magnet design easily solved this problem. The electrical connections were made through the reel spider from a slip ring on the main reel spindle. Wiring was strung in from a stationary connecting tube (see Fig. 2) to the brushholder assembly.

New replaceable-face electric brakes

Many users of Warner electric brakes are switching over to our new replaceable-face design. In most cases, this change can be made without redesign of the product. Benefits to the customer include longer wear life and easier replacement of friction surfaces without disturbing electrical connections.

The "RF" brake (see sketch) consists of three basic elements, one rotating and two stationary. The field and replaceable face are assembled as one unit, which is flange-mounted to the machine. Properly installed, the field and its electrical connections never have to be disassembled or adjusted. The replaceable-face assembly fits *over* and *around* the field, and is affixed thereto by a number of easily accessible cone-pointed setscrews. The rotating member, or armature, is hub-mounted to the shaft and driven by pins which provide automatic wear adjustment. No other electric brake, no matter how similar to the Warner design, gives you the service and wear life features of the "RF" design.

Want more IDEAS?

Send for factual application sheets showing how machines are made more productive, easier to control, simpler to maintain with electric brakes and clutches. Write to:

Industrial Products Division
Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

WARNER **ELECTRIC BRAKES & CLUTCHES**

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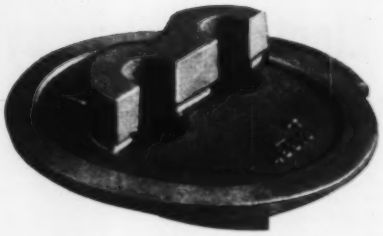
THE DODGE STEEL ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to design better steel castings

Here are a few tips on how you can obtain better steel castings through improved specification practices and design techniques. By observing these basic suggestions, you can design steel castings that meet strict service requirements, and save time and money, too!



A SOUND APPROACH

Where steel castings are concerned, efficient design goes well beyond merely creating a strong, attractive product. Too often, high unit costs, wasteful rejects, and time-consuming machining problems are designed into a steel casting *before* it reaches the foundry! Here's how to avoid some of these costly pitfalls:

It is important to establish specific service conditions for the casting. And, an accurate determination of critical requirements may make all the difference in the degree of quality as well as economy you achieve.

Unnecessary close dimensional tolerances in your design and undue variation of metal thickness will result in increased labor and material costs. If possible, contact your foundry when reducing the quantity of metal in your casting or when you have a complicated design. Sometimes thin metal sections and complexity is costly.

SELECT THE METAL

Before making your final design, it is wise to make a tentative choice of the steel to be used. A design adequate for one type of steel can cause trouble for another. The properties of steels—ranging from low-carbon varieties to high-alloy steels—vary widely in toughness, durability, and ductility, as well as in machining and weldability.

Accurate evaluation of service conditions can improve your choice. Steel castings are usually supplied normalized and drawn. Quenching, tempering, and hardening produce a broad range of properties which are best considered before making your final selection. Once the proper steel is chosen, a design tailored to its particular characteristics will often simplify foundry techniques.

IMPORTANT POINT

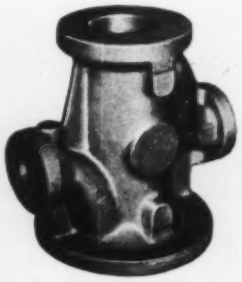
Discussing your proposed design with your foundry is highly important where costs are concerned. It's a rare case where suggestions can't be made that will simplify foundry practice and cut down on labor or material. We will be happy to have a Dodge Steel Casting Engineer discuss your design problems with you without obligation.

Send for NEW

DODGE PRODUCTS BULLETIN

This new 8-page Dodge Products Division bulletin is a "must" for those interested in securing the services of a complete manufacturing organization. It tells you how you can benefit by the research, development, and manufacturing facilities of this specialized division of Dodge Steel Company. The diverse engineering and production services—*from idea to finished product*—are described. Typical products, ranging from small machined, heat-treated components to large and complex special equipment, are shown.

Among the numerous facilities covered are milling and drilling, turning, testing and drafting, boring, welding, additive finishes, jigs and fixtures, etc. Send for your *free copy* today! Ask for Bulletin 658.



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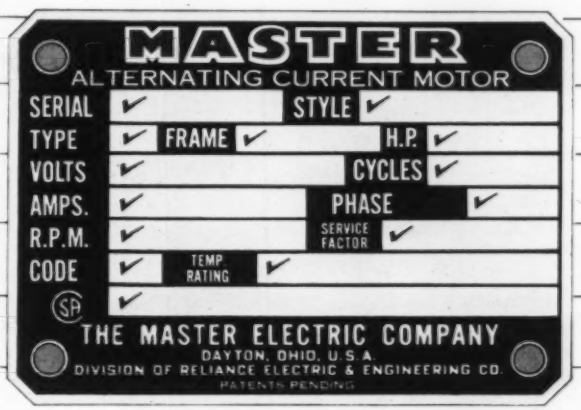

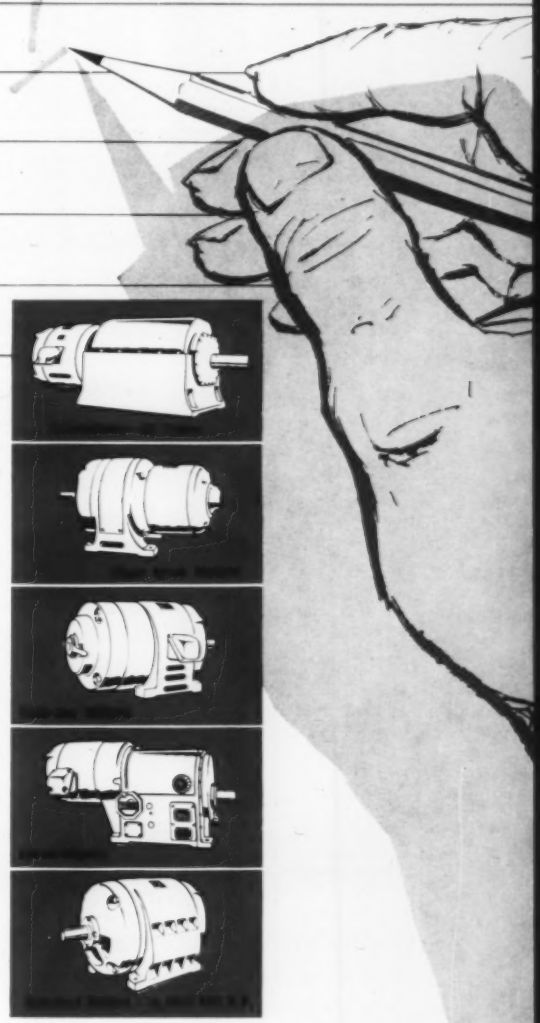

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1/8 THRU 400 H.P.

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If one of our standard motors (⅛ thru 400 H.P.) doesn't fill the bill, you'll find that all specialized Master components are engineered to form a combination of units in one streamlined, compact package of efficiency. And that's whether you need something special in gear reduction — electric or dynamic brakes — variable speed operation — fluid drive or special mountings!

Three more things you can figure on! All the engineering help you want — quality control as *you'd* want it — honest deliveries. When can we get together?

Motor Ratings... ⅛ thru 400 H.P. All phases, voltages and frequencies.

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Speeds..... Single speed, multi-speed, and variable speed.

Installation.... Horizontal or vertical with or without flanges and other features.

Power Drive Features..... Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanically and electronically controlled variable speed units — fluid drives — every type of mounting.

THE MASTER ELECTRIC COMPANY

Dayton 1, Ohio

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

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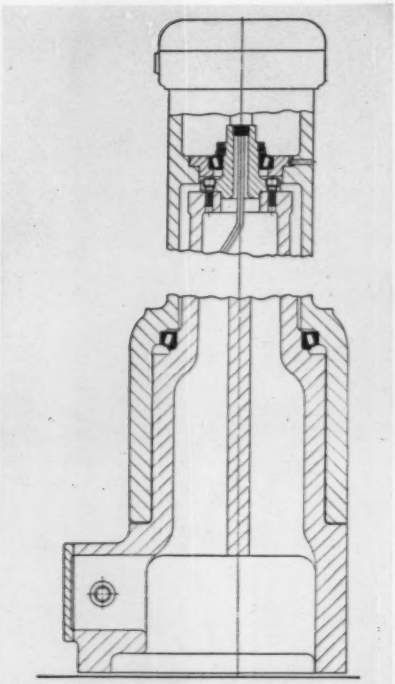
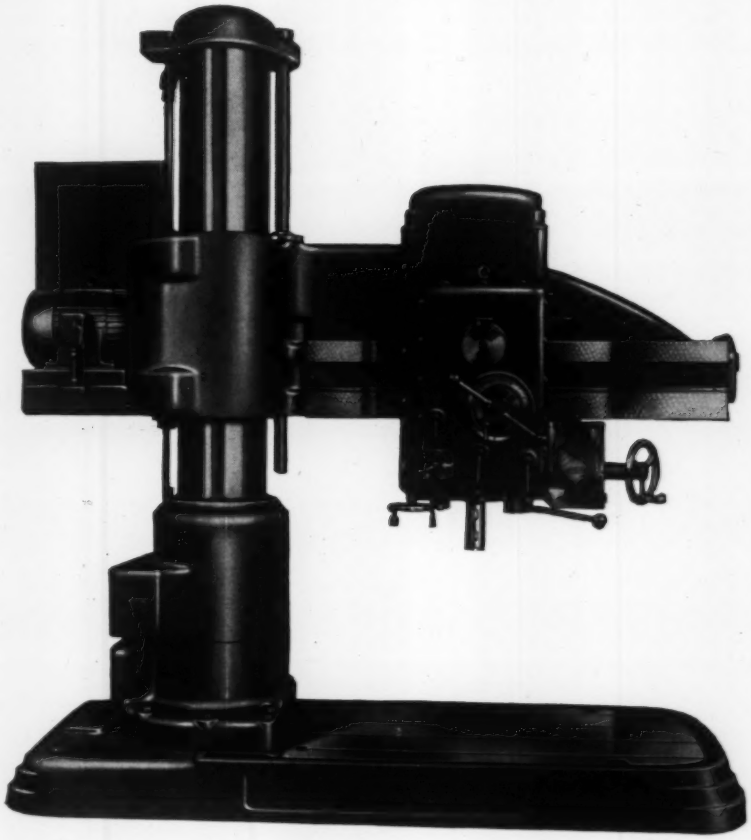


How **THE AMERICAN TOOL WORKS CO.** mounts column of 32-speed Hole Wizard Radial on 2 Timken bearings to increase rigidity 50%. Spindle and transmission use 11 more Timken bearings.



This radial drill has 50% more rigidity with column mounted on Timken® bearings

TO resist stresses and cut arm deflection in half, the column unit of this 32-speed Hole Wizard Radial is mounted on two Timken® tapered roller bearings. With a large, preloaded Timken bearing at top and bottom, The American Tool Works Company gives the column and sleeve the rigidity of a single piece. This results in greater accuracy and longer cutting tool life, permits higher speeds and coarser feeds.

HOW COLUMN IS HELD RIGID. Timken bearings keep the column unit in positive alignment. Their tapered design lets them take both thrust and radial loads in any combination. And full line contact between rollers and races gives Timken bearings load-carrying capacity to spare.

HEAVY SHOCKS ABSORBED. Rollers and races of Timken bearings are case-carburized to give them hard, wear-resistant surfaces over tough, shock-resistant cores. They reduce maintenance.

FRICTION VIRTUALLY ELIMINATED. Timken bearings run smoother, last longer, because they're geometrically designed for true rolling motion—and precision-made to live up to their design. We even make our own electric furnace, fine alloy steel—the only American bearing maker who does.

So whether you buy or build machines, it pays to specify bearings trademarked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

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